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P R O C E E D I N G S

1991 ACQUISITION RESEARCH SYMPOSIUM

VOLUME ONE

CO-HOSTED BY THE
DEFENSE SYSTEMS MANAGEMENT COLLEGE
AND THE
NATIONAL CONTRACT MANAGEMENT ASSOCIATION
WASHINGTON, DC CHAPTER

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Acquisition for the Future

Imagination, Innovation, and Implementation

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The 1991 **Acquisition Research Symposium** is the latest in a series of conferences begun in 1972. These Symposia offer a dynamic forum for dialogue among key professionals working on vital issues facing the acquisition community. Attendees include senior officials, program managers, staff officers, and researchers from the Department of Defense, federal civilian agencies, academia, and industry.

This year's theme reflects the future innovation and implementation in the acquisition process. "*Acquisition for the Future - Imagination, Innovation, and Implementation*" is the prevailing theme discussed and examined throughout this publication. The papers included cover the latest research and development as documented by individuals involved in the many aspects of the acquisition process.

We invite you to take advantage of this publication, which expands upon Symposium presentations and introduces new authors and topics. Please note that the views expressed are those of the authors and do not necessarily reflect the views of the organization with which they are associated.

Volume One is a collection of all papers presented during the Symposium.

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ACQUISITION KEYED to a SPECIFIC PROGRAM

GRANITE SENTRY: A COMMAND AND CONTROL APPLICATION OF EVOLUTIONARY ACQUISITION

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ABSTRACT

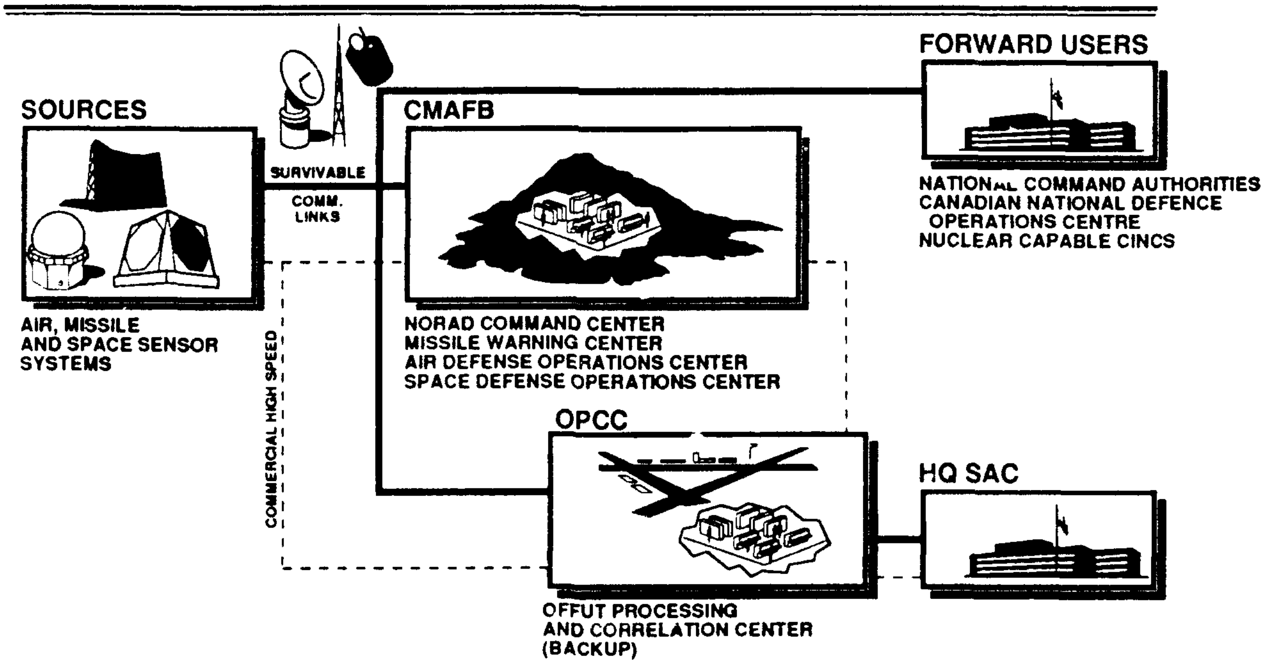
The Granite Sentry Program is responsible for acquiring mission capabilities for the North American Aerospace Defense (NORAD) Command Center, Air Defense Operations Center, Battle Staff Support Center and Weather Support Unit as part of the Air Force Cheyenne Mountain Upgrade Program. It employs several non-traditional acquisition approaches including use of contractor-assisted Government resources in a prime development contractor role, phased delivery of evolving mission capability, frequent interaction with end users and a design to budget philosophy. These non-traditional approaches can achieve significant improvements over more traditional acquisition methods as long as fundamental acquisition and engineering principles are followed. This paper examines the Granite Sentry experience in terms of its accomplishments, challenges, lessons learned and future plans.

INTRODUCTION

Program Genesis. Cheyenne Mountain Air Force Base in Colorado Springs, Colorado is the critical hub of our national attack warning and assessment system. It houses the Air Defense Operations Center (ADOC), the Missile Warning Center (MWC), and Space Defense Operations Center (SPADOC), all of which support the North American Aerospace Defense (NORAD) Command Center (NCC). The NCC and supporting centers are responsible for operating a global sensor network and for providing warning and assessment of air, missile and space attacks on defended assets for use by the President and other National Command Authorities. These operations centers are part of the National Integrated Tactical Warning and Attack Assessment System shown below.

In the fall of 1979 and spring of 1980 the computer system supporting these vital

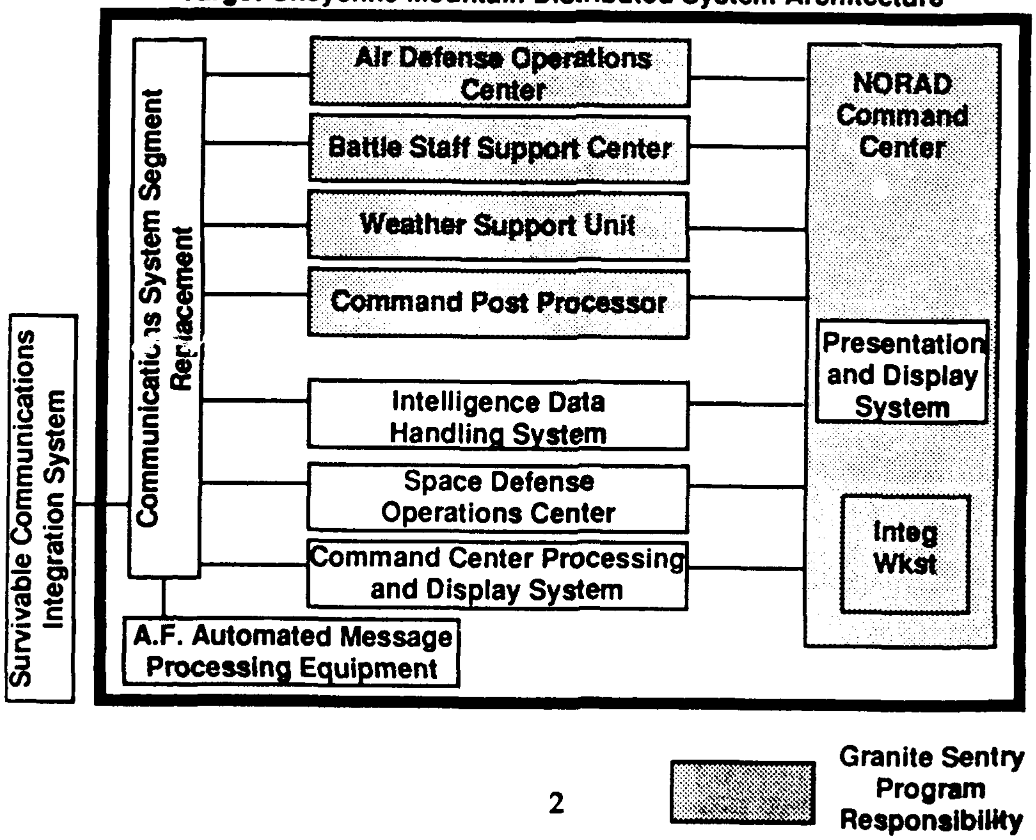
INTEGRATED TACTICAL WARNING AND ATTACK ASSESSMENT SYSTEM



Cheyenne Mountain operations centers (known as 427M) issued false attack warning indications which greatly eroded national confidence in the system. In the aftermath of those false alarms a decision was made to replace the large centralized architecture of the 427M system with a distributed one. This would allow independent computer support to each operations center and minimize the chances of a problem in one operations center affecting the others. The Air Force was also directed to acquire, operate and maintain the numerous sensors, communications and operations centers as a single system. In response to this direction an Integrated Tactical Warning and Attack Assessment (Integrated TW/AA) system architecture was established to provide a reliable, survivable national warning and assessment capability. Upgrade of the Cheyenne Mountain components to conform with the Integrated TW/AA architecture and to implement the distributed computer system concept within Cheyenne Mountain were directed by the Cheyenne Mountain Upgrade (CMU) Program Management Directive to USAF Systems Command, Electronic Systems Division. The Command Center Processing and Display System Replacement (CCPDS-R), Space Defense Operations Center (SPADOC) and Communications System Segment Replacement (CSSR) acquisition contracts were awarded in the early 80's to provide independent processing support for the Missile Warning Center and SPADOC as well as the requisite communication backbone for Cheyenne Mountain. The Granite Sentry Program was established to upgrade and/or replace computer support for all other operations centers in Cheyenne Mountain so that the older 427M system could be removed. Thus Granite Sentry is responsible for supplying automated capabilities for the NORAD Command Center, Air Defense Operations Center, Battle Staff Support Center and Weather Support Unit of Cheyenne Mountain as shown in the Figure below.

An Evolutionary Strategy. Defining detailed requirements for the Granite Sentry program was a significant problem from the outset. The Cheyenne Mountain and Integrated TW/AA architectures were still dynamic and evolving in the 1984/85 timeframe when the Granite Sentry program was established. A new U.S. Space Command was created at about this same time. The result was that the operations concepts for the Cheyenne Mountain

Target Cheyenne Mountain Distributed System Architecture



operations centers and corresponding system requirements were not well understood. In addition, cost estimates for even the top level requirements exceeded available funding by a factor of 3.

Using the traditional acquisition approach of letting a prime contract for development against an approved System Specification was clearly doomed to failure. It would require locking in evolving system requirements up front, would not produce a tangible mission improvement for several years, and would carry an exhorbitant price tag. A more flexible, design-to-cost strategy was required.

The evolutionary acquisition strategy selected for Granite Sentry [1] represented a radical departure from more traditional approaches and included several key tenets:

- The program would be acquired in five phases, each of two-year duration and overlapping the preceding phase by one year - thus the first capability would be delivered in two years with annual increments thereafter.

- A top level System Requirements Document would be developed covering all known program requirements. Dialogue with operational users would determine individual phase content and requirement priorities within a design to cost environment.

- The focus would be on getting capabilities into the Users' hands quickly and refining the capability in subsequent phases.

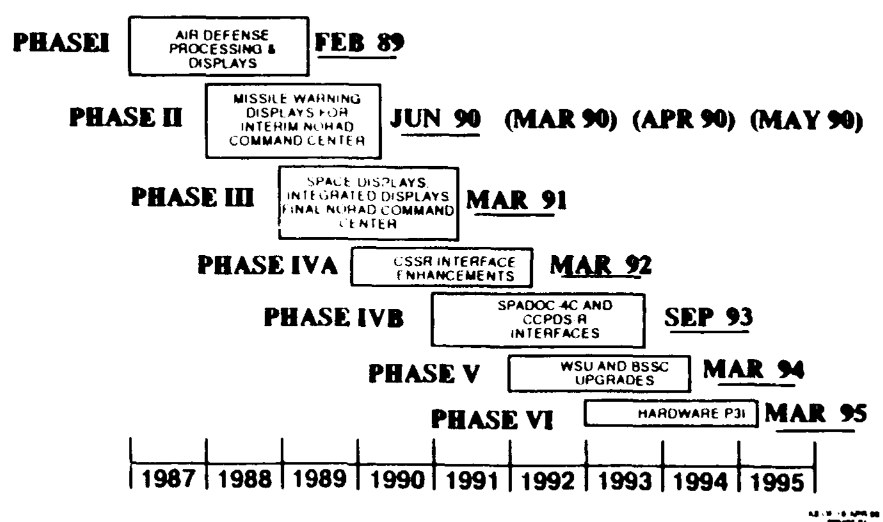
- Well understood requirements would be addressed in the early phases and less understood requirements in later phases (to allow more analysis time). The content and schedule initially established is shown below.

- Maximum use would be made of Non-Developmental Items (i.e., commercial and military off-the-shelf hardware and software) to minimize development costs. ESD would select and acquire a COTS hardware and software vendor line that could grow with requirements.

- ESD would serve as the Program Manager, System Engineer and overall system integrator; Air Force Space Command would be the mission software developer and develop the software in Ada. Both would make extensive use of level-of-effort type support contractors.

- The system development activity would be colocated with the operational user community. ESD would colocate a Deputy Program Manager and a small staff with the development activity in Colorado Springs.

GRANITE SENTRY PHASES



Evolutionary Acquisition Goals. In general, the expected benefits from this evolutionary acquisition approach were flexibility in addressing evolving requirements, a more managable design-to-cost program and improved user satisfaction with the delivered system. Specific goals included:

- Reduced acquisition costs through use of Government resources, Non-Developmental Items, and a streamlined documentation/management approach.

- Annual deliveries to users of significant capability improvements instead of one or two big deliveries after several years of "off-line" development.

- Flexibility in responding to evolving operational requirements via the phased approach.

- Delivery of a more useable system through active user involvement in the colocated development activity.

- Ability to update the COTS hardware and software architecture to keep pace with the improving state-of-the-art over the life of the program.

- Ability of the phased Granite Sentry program to adapt to changing system interface requirements as the Cheyenne Mountain Upgrade program implemented new Cheyenne Mountain and Integrated TW/AA system architectures.

The above goals are very difficult to accomplish using traditional prime development contract acquisition methods. An evolutionary approach was essential to meet the goals of the Granite Sentry program.

PHASE I - AN EARLY SUCCESS

The Development Strategy. Upgrading the processing support for the Air Defense Operations Center (ADOC) was selected as the Phase I goal for the Granite Sentry program. The planned capability would provide processing of status and track messages from forward air defense control centers. The data would be routed through the 427M Communication System Segment to Granite Sentry-provided Gateway and Air Mission processors. The Granite Sentry system would generate status and situation displays on workstations located in the ADOC crew area. The new capability would be implemented in parallel with the existing 427M Air Mission capability so the users would have a choice as to which system to use. The Air Mission capability was selected as the Phase I goal because it was well understood, had clearly defined requirements and could be developed and implemented on the 24-month schedule established for Phase I.

ESD would purchase the required processors, workstations and associated COTS software from a single vendor with a robust family of equipment and software. They would also provide overall program management and manage Granite Sentry external interfaces to other CMU systems. Air Force Space Command would manage the specification, design, coding and testing of application software and the hardware/software integration. Both organizations would use existing contract vehicles for the purchase of COTS capabilities and to augment blue suit manpower as required to get underway. Air Force Space Command would procure a computer software development support contract timed to provide contractor level-of-effort support for the coding activity of the Phase I development effort.

This strategy effectively placed the Air Force in the Prime Development Contractor role. The Granite Sentry Program Office at ESD, in partnership with the Granite Sentry Development Office at Air Force Space Command, was directly responsible for building the Phase I Granite Sentry System.

Phase I Results. The Phase I system achieved Initial Operational Capability on March 16, 1989, 27 months after program startup. Although the promised capability was delivered 3 months later than originally planned, the ADOC users were very pleased with the product and immediately began using the new system with its improved

functionality and color displays. The 427M consoles were removed several months later as the operational crews placed full confidence in the new system. The Phase I effort was hailed as a success by the NORAD user community, ESD and Air Force Space Command. The credibility of the evolutionary acquisition strategy was established.

Phase I achieved success despite significant challenges in the early going [2]. The development activity experienced great difficulty in staffing-up for the project. Many staff positions went unfilled or were filled with Government personnel inexperienced in Ada software development. Efforts to award the computer software development support contract were significantly delayed. These problems were eventually resolved through the creation of a special software development organization reporting to the Vice Commander of Air Force Space Command. But the staffing delays took their toll. A flawed initial system design had to be reaccomplished. Assets planned for Phase II development had to be used to complete the Phase I delivery on schedule. However, the relatively small slip in the Phase I schedule was minor given the early obstacles.

The benefits of colocating the system development activity with the using command and encouraging user interaction with the development process were clearly evident in the Phase I success. Requirements interpretation issues were resolved directly with the users. In many cases the developers read more into a requirement than the users had intended. During the final stages of Phase I development, a display prototyping tool [3] was successfully used to jointly define the content and organization of Phase II displays with the operational users long before Phase II coding began. The users were periodically invited to demonstrations of the evolving Phase I system in the development facility. This provided the opportunity for valuable feedback from the users and helped set the users expectations for the system to be delivered. For the first time in many years an operational system was delivered to the users without unpleasant surprises.

PHASE II - SIGNIFICANT CHALLENGES ARISE

The Development Strategy. In Phase II, Granite Sentry emphasis shifted from the ADOC to support for the NORAD Command Center (NCC). Air Force Space Command would be responsible for constructing a new NORAD Command Center Facility in Cheyenne Mountain. The Granite Sentry program would extend the computer system to add a new Command Post processor, NCC Crew Workstations and a Missile Warning display capability. ESD would acquire a Video Distribution System for the NCC to support routing of externally generated military and commercial video into the NCC. The user community also requested several enhancements to the Phase I Air Mission capability. Since preliminary performance analysis found that the Phase I workstations could not handle the Phase II processing load, a decision was made to upgrade the workstation hardware in Phase II to a more powerful suite of equipment. This decision was possible because the hardware vendor selected offered a product line capabable of growth.

Phase II Results. The concerted effort required to meet the Phase I IOC date significantly delayed the planned startup of the Phase II design and development effort. Even after Phase I IOC was achieved, many software fixes were required and continued to draw down Phase II resources. People and computer resources allocated to Phase II design and engineering in the Phase I/II overlap period continued to work Phase I development at the expense of Phase II design. Since there was no schedule reserve available to mitigate the impacts of the Phase I delays, Phase II became a schedule driven activity tasked to make up the schedule and meet the originally planned Phase II IOC date. Unfortunately, the Phase II schedule was not changed to reflect the Phase I realities.

During the Phase II development period, the external systems to which the Granite Sentry Phase II system was to interface were also evolving. The timing was such that a partial

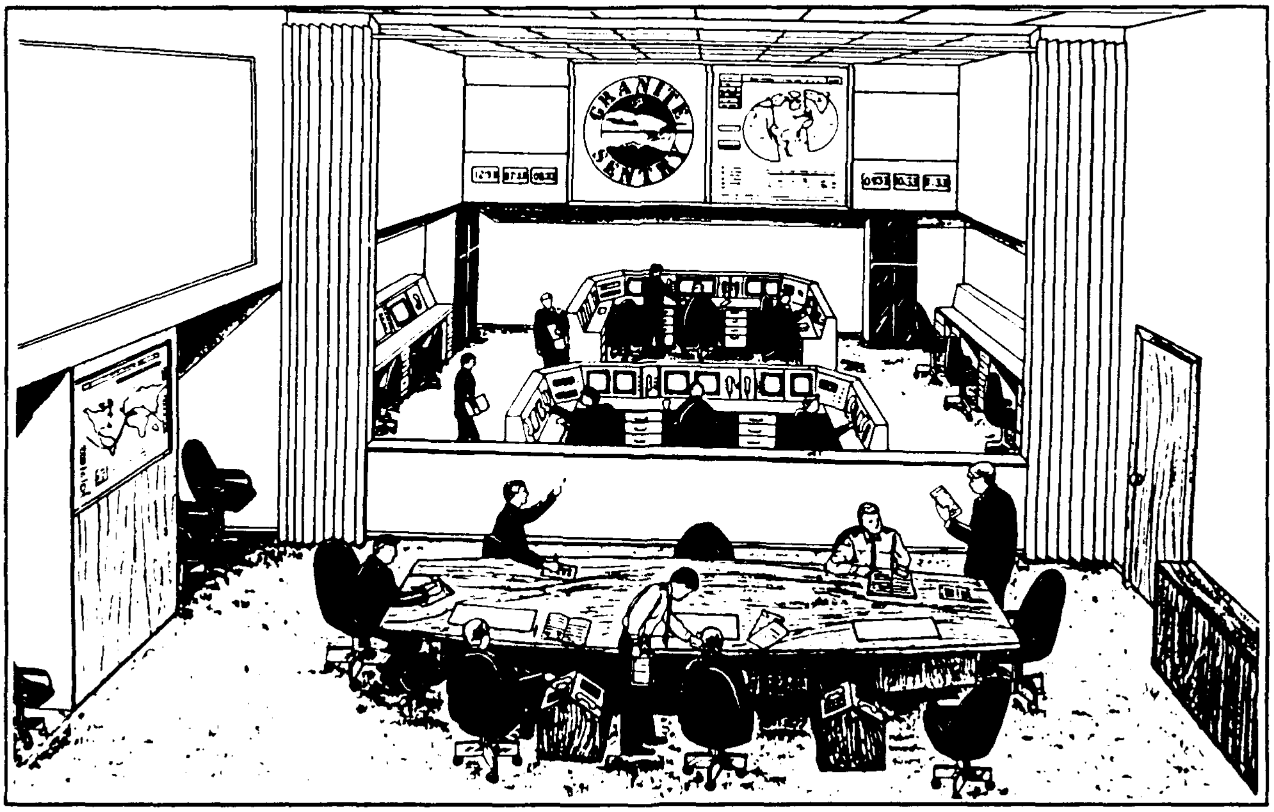
redesign was required after the Phase II Preliminary Design Review to keep pace. The magnitude of the effort required to adjust the Granite Sentry system design to evolving external interfaces was greatly underestimated. Further, resources were required to provide continuing maintenance of the delivered Phase I system which reduced resources available for Phase II.

The heavy program emphasis on COTS software became a problem when COTS capabilities were pushed further than their design intended. That led to use of the latest releases with more capabilities, but which were immature and contained bugs. Tracking down and fixing these bugs took considerable effort. Ordering and delivery delays resulted in the new workstation hardware being installed after Phase II Critical Design Review. This caused a ripple effect on the design since previously used COTS software packages were not always compatible with the new hardware.

Despite these considerable challenges, the pressure to maintain the Phase II schedule continued. Major program reviews came and went without regard for the real maturity of the system design and development products. The Phase II development staff had been working 60 hour weeks since well before the Phase I delivery. Burnout, and hence, turnover rate became high. The Phase II system entered formal testing even though the software was not ready. Not surprisingly, the requirements failure rate was high, reflecting the software immaturity. Formal testing was officially cancelled, IOC was postponed indefinitely and a period of introspection began.

ASSESSMENT AND ADJUSTMENT

Fact Finding Results. Failure to meet the scheduled Phase II IOC led to an in-depth review of the entire program. The key finding was that the Phase II effort had been significantly underestimated. The Phase II



ARTIST'S CONCEPT OF THE NEW NORAD COMMAND CENTER

software developers made significantly less use of Phase I code than planned and redesigned the entire system in Phase II. This focus on individual phases as essentially stand-alone systems caused little attention to be paid to designing for future requirements. The program signed up to providing Air Mission Enhancements in Phase II that imposed new software requirements without corresponding schedule or content adjustments. The combination of requirements growth and "back of the envelope" software sizing estimates led to underestimating the software development by a factor of 4 (70,000 lines estimated versus 280,000 actual).

Other key findings were:

- The system design and development process was undisciplined. Although good plans and policies to achieve discipline were in place, they were abandoned as being impediments to meeting the schedule. Much of the necessary design and development documentation was not maintained. Key design decisions were made by capable and well meaning staff members but were not documented and did not get the benefit of broader technical review and approval.

- The cost of delivering all of the required program capabilities had not been addressed in any depth. A quick look showed that there were far more requirements than could be delivered within approved funds over the remainder of the program. Requirements management had not been effectively accomplished.

- Granite Sentry requirements and design did not fully consider other Cheyenne Mountain Systems that were in parallel development. Some of the requirements being addressed by Granite Sentry were also being addressed by the other programs. In other cases, Granite Sentry was being designed to requirements that were incompatible with those of parallel system developments.

Adjustments. Several changes to the Granite Sentry program were instituted to address the fact-finding results. The Phase II schedule was slipped 16 months to reflect a more realistic schedule for developing the required Missile Warning capabilities - it was a bigger job than was expected. The lowest priority requirements were deferred and system performance requirements were temporarily relaxed.

A single lead contractor was selected from among the several software development support contractors and given primary responsibility for software design and development under USAF management. An effort was begun to significantly increase the discipline involved in the software development process. A program level system engineering organization was established to address requirements across all program phases instead of engineering groups for each phase. Further, an effort was begun to develop a Final Operational Capability system specification to help the designers scope the system architecture for future phases.

On the program management side, a thorough cost estimate to complete the entire program was begun. The ESD Space and Missile System Program Office's Program Planning and Management System (PPMS) [4] was used to achieve this end. All validated program requirements were identified and documented on Decision Data Matrices, then costed and prioritized according to user desires, CMU program interface requirements and approved funds. Many requirements were only implicitly identified (e.g., by an Operations Concept) or reflected outdated approaches to achieving CMU (i.e., "system of systems" level) program objectives. This necessitated a revalidation of program requirements that is still ongoing. Initial costing results showed that the cost of implementing all remaining requirements exceeded approved funding by a factor of 3. This prompted a review of implementation alternatives that could achieve high priority user requirements, meet CMU program requirements and be accomplished within approved funds. The objective of this review was to reduce the Granite Sentry software development workload by taking advantage of the capabilities already under parallel development in other CMU programs to

assure an integrated CMU implementation. The PPMS process also supported planning for program management, testing, training and operations and maintenance costs to enable comprehensive budget planning for total program execution. The PPMS budget products provided an excellent vehicle for coordinating program requirements and funding within the Granite Sentry program itself, with other CMU programs, with the NORAD user community and supporting organizations (AFLC, ATC).

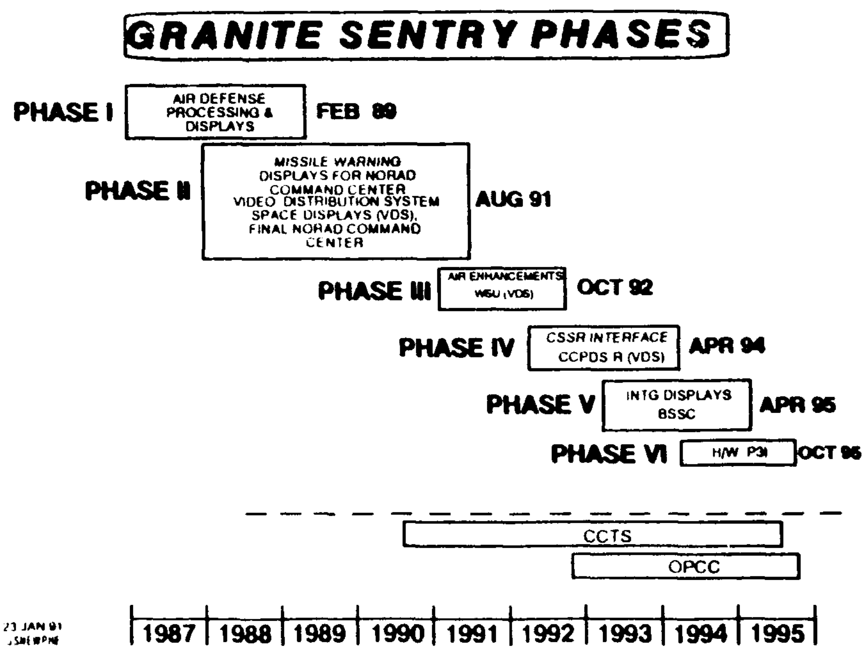
The rescoping and rescheduling of future phases of the Granite Sentry program is currently underway. The goal remains to get effective mission capability into the users' hands quickly and within approved funding. The challenges encountered in Phase II have surfaced valuable lessons that will help assure the success of future program phases and demonstrated the viability of the evolutionary acquisition process to respond to changing needs.

LESSONS LEARNED

System Requirements Management. In an evolutionary acquisition environment, it is imperative that required capabilities be individually defined, costed, prioritized and baselined. Failure to treat each capability individually precludes trading off one capability for another under the design-to-cost strategy. Failure to accomplish such tradeoffs as new requirements arise leads to overcommitments and an inability to deliver within approved funding and schedule constraints. Missed deliveries rapidly elevate user dissatisfaction and erode their confidence in the acquisition process. It is much better to address the requirements issues with the users head-on as they occur than to allow the requirements baseline to grow to undeliverable proportions.

Requirements must be treated in a highly disciplined fashion. This does not mean that they cannot be changed, added or deleted, just that the process cannot be informally accomplished without significant risk to the program. When requirements change, the cost and schedule impacts must be formally considered and incorporated into the baseline by a System Program Office-controlled Configuration Control Board. The Program Planning and Management System we used in Phase II is an excellent vehicle for accomplishing such formal control. As a minimum, an annual review of the requirements baseline and remaining funding and schedule is essential.

User involvement in the evolutionary development process is a two-edged sword. Frequent interaction with the users (enabled by colocating the development activity with them) offers a tremendous advantage in



achieving user acceptance of the delivered system - they know what they are getting well before final delivery and their involvement makes them shareholders in the success of the product. They can also quickly identify any misinterpretation of the stated requirements (in many cases we were trying to give them more than they needed or wanted). But there is also a down side. Direct user access to the developers can result in fine tuning of the implementation more appropriate to the Operations and Maintenance phase of the system lifecycle. As the users grow accustomed to new capabilities, their desire for additional enhancements to add new functionality contributes to "requirements creep" and thus, growth in the original requirements scope. Also, users are typically locked into current operations concepts and have difficulty projecting into future concepts developed by more visionary, senior decision makers. The result is a constant pressure to make the new system operate like the old system it replaces whether it complies with future target architectures or not. The advantages far out weigh the disadvantages, however, and bringing the development organization close to the users is a net plus.

Upgrading capabilities delivered in the last phase during the phase currently in work is a big mistake. By the time the users get their hands on the product produced in the earlier phase and determine what operational improvements they desire, the current development phase is already through its design process and into coding. With an overlapping phasing strategy, its better to defer new requirements to the beginning of the next full phase.

Slipping requirements implementation from one phase into the next is equally bad for the same reasons. There can be a very strong temptation to defer requirements that were promised in a given phase but which could not be fully implemented (due to schedule or resource constraints) until the next phase. Doing so places an unpredictable burden on the next phase since people resources have been allocated for the new phase. It is better to recognize that some promised capabilities may not get implemented in a given phase and, if so, they must go back into the pool of requirements to be allocated to future phases. Deferring requirements from one phase to the next increases the risk of failing in the next phase.

In an evolutionary, design-to-cost environment, periodic requirements review and prioritization is critical. Initially, requirements must be accurately traced from validated source documents, such as a System Operational Requirements Document, into an approved Acquisition Program Baseline so that a basis will exist for determining new requirements. Any significant changes to existing requirements or the addition of new ones should trigger a program level review and reprioritization of all of the requirements.

If a system is part of a larger overall system, such as the Integrated TW/AA system, requirements levied on ITW/AA component systems must be reconciled with those levied on the other component systems and with the overall objectives of the larger system. System-of-Systems level requirements and the concepts for achieving them are continually evolving. Component system requirements tend to reflect a snapshot of the current thinking at the time of program startup and may be incompatible with interfacing component programs established earlier (or later). Component system requirements should be revalidated periodically and the component program should be an active participant in the system engineering of the overall system of systems.

Requirement changes must be formally assessed for cost and schedule impact and the baseline adjusted accordingly. To avoid getting lost in the forest, a requirements working group should be chartered and meet regularly to make sure the program as a whole is achieving approved program objectives. Otherwise, requirements creep will assure failure to deliver within approved schedule and funding and the resultant system may fail to achieve some of the goals established for the program.

System Design and Engineering. Engineering an evolutionary system poses

unique challenges since all of the requirements for the final system are not known at the outset. Intermediate capabilities may also come and go over the development cycle. But it is a mistake to design the system on a phase by phase basis without regard to the final operational capabilities to be delivered. An FOC goal must be defined and an "open" architecture established to provide a robust backbone around which future capabilities can be developed. System functions should be kept decoupled to the greatest extent practical and the system capabilities and throughput should be designed for growth.

Use of commercial-off-the-shelf (COTS) software can be highly effective but should not be depended upon too heavily, especially when new, state-of-the-art software is used. COTS software has bugs like any other software. Isolating and correcting the bugs is time consuming and can impact the development schedule. Also, COTS capabilities are often driven by commercial applications that pose far less stringent performance demands *than* C2 applications. COTS software performance can become the limiting factor in system design and should be chosen carefully. Prototyping planned COTS implementations can help identify problems early and mitigate these risks. Having the COTS original equipment manufacturer on contract to support the development activity and assist in fixing bugs is essential in taking full advantage of COTS capabilities.

Planning for the need to redesign and redevelop portions of previously delivered capability must be done. New or improved COTS and application software used in the current phase may not be compatible with that delivered in an earlier phase. Granite Sentry Phase I used a 2-D graphics package but Phase II needed 3-D graphics. This required maintaining two graphics packages or recoding Phase I displays as part of the Phase II development. About 25% of the effort in each phase should be reserved for reengineering to achieve compatibility across phases. The need to maintain the capability delivered in previous phases while developing each new phase must be planned for. It must be recognized that changes in the current operational system environment can impact both previously delivered capabilities as well as those under development.

Program Phasing and Scheduling. The overlapping phase development approach works well as long as two conditions are met: the specific development discipline (e.g., design, coding, testing) of one phase cannot overlap the same discipline in the next phase; and the same people cannot be used to do multiple disciplines within the same phase. This allows effort in one phase to be decoupled from those of the next phase and minimizes the impact if an earlier phase slips its schedule. Two years is an absolute minimum phase length if significant software development is required (30 - 36 months would probably be better).

Phase content should not be evenly distributed across all phases. Doing so causes one phase to impact all remaining phases if problems occur. Alternating light and heavy phases could help mitigate this problem and provide developmental *windows*, during light phases, for addressing new user requirements.

Bad news does not improve with age. When problems appear, recognize and deal with them. Talk to the users, adjust the schedule and/or scope for the phase to make it realistic. Avoid the temptation to rigorously hold to the schedule and hope it will all work out somehow.

Flexibility versus Discipline. The flexibility offered by the evolutionary acquisition approach is often in conflict with the discipline customary on more traditional acquisitions. The latter typically requires the prime development contractor to develop and deliver a plethora of plans, design documents and other formal deliverables. Given the relatively short evolutionary development phase there is a strong tendency to eschew such formality and pursue a "skunk works" style that focuses more on the product than the process used to produce it. But too little discipline is as bad as too much in an evolutionary development program. While many corners can be cut to streamline the

process, fundamental principles must be pursued in a formal disciplined fashion as follows:

- requirements must be formally defined, costed, prioritized and managed.

- system engineering must produce and baseline system architectures, performance models, technical performance measures and trade study documentation of design-driving decisions.

- software designs need to be formally validated, baselined and managed within the context of known future requirements and architecture.

- formal configuration management of the developing system is crucial in the fast-paced, dynamic environment of evolutionary development.

- the most experienced people on the project staff who have accrued hands-on system development wisdom should decide which traditional disciplines can or cannot be eliminated.

CONCLUSIONS AND RECOMMENDATIONS

A Viable but Demanding Approach. The evolutionary acquisition approach used on Granite Sentry had distinct advantages over traditional Command and Control System acquisition approaches.

- It delivered an Air Defense Operations Center replacement system in Cheyenne Mountain in just over two years.

- It delivered a system that the ADOC users are happy with and use as their primary operational system.

- The phased implementation concept achieved requirements stability since the users knew they could adjust requirements in later phases.

- It is far more flexible and responsive to changing requirements and to changing COTS technology over the life of the program.

- It provides incremental delivery of mission capability throughout the life of the program and far more quickly than conventional approaches. Even considering the schedule slippage experienced in Phase II, we will deliver a Missile Warning mission capability in about half the time required by traditional approaches.

However it is a far more demanding approach from an acquisition program management standpoint. In an evolutionary acquisition, the System Program Office must assume many of the management responsibilities typically accomplished by a prime development contractor. For example, more detailed program management planning is required to define charters, and orchestrate activities and manage the contracts/funding of the many players comprising the development team. Other areas of increased involvement include requirements control, cost estimating and monitoring, schedule maintenance and the conduct of formal project reviews. The diversity of the development team requires a concentrated effort to establish and maintain communications at all technical and management levels. The emphasis on user involvement requires frequent briefings to report status, solicit requirements priorities and sell implementation approaches. Thus, it requires substantial program office involvement.

Recommendations for Other Programs. The evolutionary approach used on the Granite Sentry program has applicability for other programs as well. It is well suited to Command and Control and other information management/display systems (e.g., Intelligence systems) having only partially understood and/or dynamic requirements but with fixed implementation budgets. The approach requires strong management to be successful but pays high dividends in terms of user satisfaction. For those considering a similar evolutionary approach we offer the following recommendations:

- Control requirements formally using a system like PPMS and carefully assess the costs of new or changed requirements.

• If multiple support contractors are used for software development, select and assign one of them lead responsibility for software development. Have the COTS Original Equipment Manufacturer on-board. Structure the contracts to provide accountability mechanisms in the Indefinite Delivery/Indefinite Quantity environment.

• Identify or establish a flexible contract vehicle to acquire COTS hardware and software. Budget for upgrades and replacements over the life of the program.

• Provide resources to support maintenance of earlier system deliveries as part of the development team.

• Build in a workload management reserve in each phase or use alternating light and heavy phases to provide opportunities to address unanticipated work.

• Colocate the development activity and System Program Office elements with the system users. Stay close to the user organization; listen to what they say and make sure they understand the relative cost consequences of their requirements so they can take these costs into account when they prioritize requirements. Formally review all requirements changes.

• Do not get carried away with informality and process streamlining; strive to make the program as formal as it needs to be to maintain overall control.

The Granite Sentry program continues to refine its pioneering acquisition approach with the straightforward goal of satisfying the users' mission needs within the approved cost and schedule. Much work remains to complete that goal, but we have confidence that this evolutionary approach will deliver more capability into the operational users' hands more quickly than traditional approaches.

ACKNOWLEDGEMENTS

The authors wish to thank the many members of the Granite Sentry community who assisted in the review and improvement of this paper. Special thanks are due to the members of Air Force Space Command, the Martin Marrietta Corporation, Digital Equipment Corporation, CTA INCORPORATED, Sumaria Systems Inc., and the Mitre Corporation who provided substantive insights and editorial help in the preparation of this paper.

ENDNOTES

1/ Source: Granite Sentry Program Management Plan, June 30, 1987

2/ See "Cheyenne Mountain System Acquisitions: Problems and Principles", May 1990, Ellis K. Conoley, Lt Col, USAF

3/ The tool used was the Rapid Intelligent Prototyping Laboratory (RIPL), a proprietary CTA INCORPORATED User-System Interface prototyping capability.

4/ See "The Program Planning and Management System and Its Use in the Management of a Space Program", James E. Jacoby, Major (Col), USAF. The PPMS process and associated automated support tools are curently in use within the Space and Missile Warning System Program Office at Headquarters, ESD.

SOLE vs. MULTI-SOURCING IN WEAPONS ACQUISITION: THE CASE OF AIR FORCE JET ENGINE PROCUREMENT

Cadet First Class Scott D. Banks, USAF Academy
Major Kenneth J. Reynolds, USAF Academy

ABSTRACT

This paper examines the role of dual sourcing in determining the price of Air Force jet engines. When suppliers (sellers) of products operate in a sole source environment (i.e. only one seller), one should see price determined by allowable costs of production, a "fair" rate of return and a markup stemming from the lack of competition. The significance of this markup depends on the degree of market power (monopoly power) possessed by the seller and his willingness to use this market power in price determination. The degree of market power is dependent upon the magnitude of investment the seller commits to this particularly exchange or transaction and the availability of alternative suppliers of the product as well. If the seller aspires to use this market power and is successful in doing so, then a markup in price would occur. Even in the face of competitive bids which result in sole source awards, markups in price may occur *ex post* given the length of the contractual relationship and the existence of and the desire to use market power. We test the significance of this markup using a panel data set developed from Air Force jet engine procurement contracts exhibiting both sole and dual source (two or more sellers) environments and conclude the markup is insignificant. This suggests the Air Force dual sources for reasons other than strictly reducing price of jet engines.

INTRODUCTION

The strong attention the media has focused on the deficit has Congress and the White House looking for ways to reduce government expenditures and possibly increase taxes. Due to the vast procurement expenditures in the Department of Defense (DoD), external as well as internal scrutiny has focused on the DoD procurement process. Specifically, many changes have been initiated over the last decade by Congress and DoD to streamline DoD procurement thus improving its overall efficiency. One strategy resulting from the plethora of suggested reforms has been that of dual sourcing or the appropriate use of competition to lower price of the product being procured.

The Air Force has implemented dual sourcing strategy in a number of procurement programs with differing degrees of success. Some examples would include the MAVERICK and AMRAAM air-to-air missiles and jet engines built for the Air Force's F-15 and F-16 fighter aircraft. The first two cases are illustrations of the second source building a competing product from the documentation of the initial source. The jet engine case represents a true alternative second source developed independently of the first source. It is this case that we now turn our attention to.

The paper proceeds as follows. The next section is a discussion of the economic rational for dual sourcing. It provides the framework for deriving testable hypotheses regarding the effect of sole *versus* dual sourcing on product price, which forms the basis for the empirical work that follows. Section III details hypotheses derived from the economic rational of dual sourcing. Section IV is a description of the panel data set used in our analysis while Section V features the results of the empirical estimation. We conclude in Section VI with policy recommendations suggested by our results.

ECONOMIC RATIONAL FOR DUAL SOURCING

According to Ruffin and Gregory, "A firm that has monopoly power has the ability to control (select) prices of its products. Such a firm is called a *price searcher*. The greater is the

monopoly power, the greater is the control over price. Most firms are price searchers."[1] Intuitively, this means a *firm charges* a higher price for a product in a sole source environment than it would producing the same (or similar) product in a competitive environment. This implies price in a sole source environment is not just a function of costs and a fair rate of return, but instead a function of costs, fair rate of return plus some markup stemming from the monopoly power. The markup is measured as the difference in price assessed for the same (or similar) product in a sole source environment *versus* a competitive environment.

The magnitude of this markup is dependent upon the degree of monopoly power that a firm possesses. The degree of monopoly power is dependent upon demand and cost conditions that the monopolist faces. Concerning demand, the priority the buyer places on purchasing this particular product influences the degree of markup. The greater the need of the buyer, conceivably the more that buyer is willing to pay, hence the greater the markup. Also, the degree of product complexity affects the markup. If a product is fairly complex to produce, this suggests alternative sources of supply can not be inexpensively or immediately developed, hence potential escalation of the markup by the seller may occur.[2]

Since a monopolist charges a higher price relative to the competitive price and faces a downward sloping (market) demand curve, quantity produced at the monopolist price would be less than market quantity (i.e. summation of individual competitive firms' output) produced at the competitive price. The resulting inefficiency (less production in the case of monopoly) means the economy is worse off (meaning less efficient) than in the competitive case. Intuitively, this indicates it is possible to improve economic performance (i.e. economy is more efficient in the sense of giving more to everyone) by allocating more resources to production of the monopoly product thus bringing monopoly output closer to the competitive output level. Less resources are then allocated to the production of other goods consequently decreasing their output levels (i.e. reallocation of some resources away from other goods to the production of the monopoly product would actually increase total production in the economy).[3]

Because a monopolist charges a higher price and produces less output than its competitive counterpart, one might posit that moving from a sole source to a dual source environment would coerce a procurement process into being more efficient. Quite simply, more quantity might be procured at a lower price in a dual source environment relative to a sole source environment. This rational seems to fit the case of weapons procurement in DoD. Many weapons are technologically complex and significant supplier investment is required to produce them. Usually the priority of this type of procurement is quite high relative to other DoD procurement programs. Finally, in DoD we do see some of these programs sole sourced initially and then dual sourced during the production stage.[4] The question then to postulate is this: "Does DoD reduce the price (markup) of these items through dual sourcing? Or to put it another way, is there in fact a markup in price in sole source environments that may be reduced through the use of dual sourcing?"

HYPOTHESES

Hypothesis 1: <u>As the quantity of product (engines) produced increases, unit product (engine) price should decrease</u>.

Movement of the firm's average cost is negatively correlated with increases or decreases in the quantity of engines produced. That is, as quantity of engines produced increases, the firm's average and marginal cost[5] per engine should decline until the firm approaches maximum plant capacity. A firm's startup costs are quite significant when positioning physical capital to begin production. In many instances, a firm must also recoup substantial research and development costs as well as overhead costs during the production phase of the procurement process. These costs are amortized

over the quantity of engines produced; consequently, the more product (engines) produced, the lower these average costs.

Hypothesis 2: As the firm experiences a "learning curve effect", the unit product (engine) price should decrease.

As firms become more familiar with new production processes, they recognize potential problems quickly and deal with them in an expedient manner. In addition to this, firms may be able to improve the overall production process by learning from past experiences thus making the production process more efficient. Product (engine) price per unit should decrease given a learning curve effect.

Hypothesis 3: As input prices increase, the unit product (engine) price should increase.

Input costs are an important factor in determining the final unit price of an engine. Some inputs required to produce engines are steel, cobalt, titanium, nickel, skilled and nonskilled labor. As labor or material costs rise, the unit product (engine) price should increase.

Hypothesis 4: As the market environment moves from sole to dual source, the unit product (engine) price should decrease.

Sole source production models monopoly production--only one firm producing a product which has no close substitutes. Price in this environment is a function of average costs and a markup reflecting the degree of market or monopoly power. The introduction of competition through dual sourcing diminishes a firm's monopoly power thus negating that firm's ability to institute a markup when setting price. Dual sourcing delivers lower unit product (engine) prices relative to a sole source environment.

DATA

A panel data set was collected for this analysis from agreements under which the Air Force procured engines for F-15 and F-16 aircraft from two different suppliers, Pratt and Whitney and General Electric. Data was obtained from basic jet engine contracts and modifications to those basic contracts. These modifications are used to change terms and conditions of basic contracts such as delivery dates, quantity of engines sold, price of engines, technical requirements or an agreement to pursue future options for engine procurement. The modifications to the basic contracts may be issued unilaterally by the Air Force, or bilaterally agreed to by both contractual parties. Thus, our observations are either (1) terms and conditions (i.e prices, quantities) from basic contracts or (2) bilateral agreements to the basic contracts. We have one hundred and eighty-two firm-specific observations between the Air Force and the two engine suppliers starting in 1977 and ending in 1989. The engine was sole sourced from Pratt and Whitney until 1984 when competition was introduced through General Electric's independently developed alternative engine.

Proxies. Information was collected on prices and other independent variables that serve as proxies for the empirical relationship hypothesized above. The independent variables used to explain the variation in PRICE were QUANT, SUMS, ENGINE, TITAN and SOURCE.

PRICE, the dependent variable, is the nominal dollar amount the Air Force paid for an engine. Nominal prices were taken from basic contracts and modifications to those contracts. These nominal prices were then adjusted for inflation using 1982 as the base year.

QUANT is the number of engines procured at a particular date for a particular price per engine. As the quantity increases, price should decrease suggesting a negative coefficient for QUANT.

SUMS is the cumulative total number of engines procured from a particular firm at the time of the observation. The first observation by a firm would be the initial quantity procured by the Air Force. The second and all subsequent observations by a firm would include all previous engines

procured from that firm plus the quantity procured at that particular observation. As the learning curve takes affect, the price of the engine should decrease implying a negative coefficient for SUMS.

ENGINE is the average hourly earnings for workers producing aircraft engines and engine parts adjusted to reflect 1982 dollars. This data were obtained from Employment and Earnings.[6] As firm's wages increase, engine prices should increase insinuating a positive coefficient for ENGINE.

TITAN (Titanium) is the producer price index for titanium mill shapes. Data came from the Producer Prices and Price Indexes and was adjusted to a 1982 year base. As the price of titanium increases, the price of the engine escalates signifying a positive coefficient for TITAN.

SOURCE is a qualitative (dummy) variable used to measure the markup in price between sole and dual source environments. For observations occurring during the sole source environment, a value of zero was assigned. The value one was assigned for observations occurring during the dual sourcing environment. As the contractual environment shifts from a sole source environment to a dual source environment, engine price should drop meaning SOURCE should have a negative coefficient.

Table 1

Coefficient	Equation One	Equation Two
CONSTANT	418243 (0.227) {0.821}	2781106 (21.5) {0.000}
QUANT	-9109 (-1.54) {0.129}	-2507 (-1.94) {0.052}
SUMS	640.8 (0.82) {0.416}	-102.51 (-1.67) {0.095}
SOURCE	556355 (0.52) {0.605}	---
ENGINE	144848 (0.99) {{0.329)	---
TITAN	-328.68 (-0.12) {0.902}	---

Where the first row of numbers is the coefficient values, the second row is the t-ratios and the third row is the level of significance. The number of observations was 182 and the dependent variable was PRICE.

EMPIRICAL ESTIMATION

The following relationship was estimated:

$$PRICE_{it} = \beta_1 + \beta_2 QUANT_{it} + \beta_3 SUMS_{it} + \beta_4 ENGINE_{it} + \beta_5 TITAN_{it} + B_6 SOURCE_{it}$$

where the *i,t* subscripts denote contractor *i* at date *t*.

The results are presented in Table 1. At first glance, the results may seem somewhat discouraging at best, but after careful scrutiny that does not seem to be the case. The first equation was run as theory predicted it should be. None of the explanatory variables (plus the constant) are of any significance in explaining the variation in the dependent variable price.[7] A firm-specific dummy variable was run with this equation to see if firm-specific effects could significantly explain variations in the dependent variable price but it was insignificant.[8] Only QUANT and ENGINE were of the correct sign. We did run different variations of this model to glean more information, but the only model that was significant was equation two reported in Table 1. In all cases, SOURCE, our proxy for the markup one should see in a sole source environment, was insignificant. The second equation reported in Table 2, showed the constant term, QUANT and SUMS significant at the one percent level, five percent level and the ten percent level respectively and of the correct signs. In equation 2, the significant constant (intercept term), approaches the average per

unit engine price.

Does this mean the theory is wrong? Not necessarily. What our results seem to suggest is that QUANT is a proxy for input prices. If QUANT is a proxy for the other explanatory variables as well, this explains the results obtained from estimating equation one.

Increasing engine quantities also imply increasing resource quantities that must be procured by the firm. If Pratt and Whitney and General Electric face downward sloping derived demand curves for resources, then per unit resource price should decline even though total resource cost would increase. At the margin (i.e. increasing engine quantity by very small amounts at a time), unit engine price then might decline which again is captured by QUANT increasing marginally and effecting a lower price.

A separate consideration that should be explored regarding input prices is the fact that in many instances inputs are contracted for at a fixed real (inflation adjusted) price over the life of the engine contract. This means input prices would not vary except in the case of changes in quantity of inputs purchased. Therefore, there would be no variation in engine price coming from TITAN except when input quantities changed. Instead, the variation in engine price would again be captured by the change in QUANT which caused input quantities purchased by the two firms to vary.

The lack of significance of ENGINE is puzzling. We would suggest that again QUANT is a proxy for input prices. Real wages may not be varying significantly over the duration of engine contracts because of agreements between both firms and labor unions which keep real wages constant. Both firms may also have salary agreements of some type with management which hold real salaries somewhat constant as well. In this case, no variation in per unit engine price would be explained by ENGINE.

SOURCE was not significant nor of the correct sign in any variation of the original model. This does suggest the Air Force dual sourced this particular engine for reasons <u>other</u> than lowering the per unit engine price. Does this imply there is no markup resulting from monopoly power in the sole source environment? No, it does not. Our results do not suggest there is no markup in engine price in the sole source environment. Our results do suggest that if there is a markup in sole source per unit engine price stemming from monopoly power, it is insignificant when compared to the per unit dual sourced price of the engine. Again, our results strongly suggest this engine was dual sourced by the Air Force for reasons other than per unit engine price reduction.

CONCLUSIONS

Our results do form the basis for policy recommendations. The fact that quantity is highly significant in equation two suggests the Air Force must strongly consider total quantity over the life of the procurement program as well as annual production rates. Anecdotal evidence of this is seen in Robert Drewes book titled <u>The Air Force and the Great Engine War</u>: "To continue to see [competition] work, the Air Force needs high total volume over the entire program and a high enough annual production rate. In explaining the engine competition to the House Armed Services Committee, Dr. Tom Cooper said, 'On this particular program [Alternate Fighter Engine] we are looking at 3,000 engines ... trying to get dual sources on 50 C-5 engines probably doesn't make sense.' The volume over the entire program and the annual production rate must be high enough to justify the fixed costs of supporting two manufacturers. The exact breakeven point, where the cost of one versus two sources is equivalent, will vary depending on the specific programs and contractors involved."[9] Referencing the fixed costs of supporting two manufacturers mentioned above, after several discussions with Air Force program managers and contracting officers, we suggest a neglected significant portion of this fixed cost is the administrative burden to the Air Force of maintaining separate procurement teams for each supplier. The Air Force must have a complete

procurement team (e.g. contracting officers, engineers and other specialists involved in the procurement process) for each firm. This significantly increases Air Force requirements (costs) to administer and govern procurement processes in dual source environments. Again, Congress, DoD and the Air Force must consider total quantity over the life of the program and the annual production rates when considering dual sourcing.

There are other reasons the Air Force may have had for dual sourcing this engine which are perfectly valid when considered from an economic, institutional and policy perspective. We will dwell only on three even though there may be others. The first reason we suggest is that of attempting to control opportunistic behavior by the sole source firm, Pratt and Whitney. According to Air Force contracting officers possessing a working knowledge of this procurement program, Pratt and Whitney had become increasingly difficult to deal with from 1970 to 1975. The engine was experiencing several problems yet Pratt and Whitney was not correcting those problems as promptly as the Air Force requested. Citing Robert Drewes book again, pages 55 and 87: "One of the most disturbing aspects [of the relationship between Pratt and the Air Force] concerned the Air Force perception that Pratt was more interested in generating profits through contract changes than in making the engine perform properly. ... The Air Force leadership felt that if they went to Pratt to discuss technical problems, instead of meeting engineers and other F100 [Pratt's engine] program people, they would meet Pratt attorneys. The Air Force knew that the good solutions of Pratt's engineering staff were not getting past their management as quickly as the Air Force wanted because of haggling over business terms. So at an Atlanta airport hotel, the Air Force and Pratt met quietly and produced some much needed quality, independent research. ... Because of the effects of total dependence on one engine, the Air Force resolved to get a second source. The accumulation of F100 problems, Pratt attitudes, and the strikes [labor strikes at two Pratt key suppliers] jelled united commitment to bring along the GE engine." With the intimidation of competition, opportunistic behavior should diminish implying less effects on contractual performance. This means an improved relationship between buyer and seller which facilitates the complete procurement process.[10]

The second and third reasons for dual sourcing may be to improve quality of the engine and lower the price of other items that must be procured along with the engine but at separately negotiated prices. Air Force contracting officers noted that at one time in 1989, the Air Force was considering dropping part of the warranty on Pratt and Whitney's engine because of its operational reliability. They stated the reliability of this engine had improved significantly since the introduction of competition. In addition to this, the contracts showed a substantial decrease in the price of warranties. Contracting officers stated that with the introduction of competition, the Air Force gained leverage in negotiations which allowed them to obtain concessions from suppliers in areas other than engine prices, specifically warranty prices.

The decision to dual source is a complex process for Congress and the Department of Defense. Each procurement program in DoD is reviewed to determine the best acquisition strategy, sole or dual source. In considering this decision, our results suggest that (1) total quantity over the life of the program and the annual rate of production should strongly be considered, and (2) there are other convincing reasons to dual source than just the reduction in price of the product. With the introduction of competition, potential improvements to the procurement process may occur which significantly facilitate contractual performance. This does <u>not</u> mean that dual sourcing is the best acquisition strategy for each procurement program.[11] It means that in evaluating each acquisition program to determine the suitability of competitive strategies, the goals to be obtained through competition <u>must</u> entail more than just a

reduction in price. The Air Force's decision to bring on board an alternative supplier, in this case, was economically and institutionally appropriate.

ENDNOTES

1/ See Ruffin, R. J. and Gregory, P. R., Principles of Microeconomics, Fourth Edition, Illinois: Scott, Foresman/Little, Brown Higher Education, 1990, for a detailed discussion of monopolies. A monopolist in this text is defined as one seller in the market producing a product or service that has no close substitutes.

2/ This becomes more of a possibility if the buyer is procuring the product as an intermediate good to be used in the construction of an end or final product. In this case, the seller, knowing the buyer cannot risk an interruption in the delivery schedule of the intermediate good because of the likely deleterious effects on the delivery schedule of the end product, may "holdup" the buyer. The seller is anticipating the buyer will agree to raise price rather than confront the likelihood of significant losses from slipped delivery schedules. It should be noted that buyer "holdup" is a possibility as well; however, history has shown us this usually is not the case. Alternative buyers are customarily "easier" to find than alternative suppliers. This is because of the substantial investment required by the supplier to produce a technically complex product such as jet engines.

3/ See Ruffin and Gregory (reference endnote one), Chapter Eleven, for a more complete discussion of this subject.

4/ Some examples of dual sourced DoD programs are PHOENIX, SPARROW, PHALANX GUN SYSTEM, TOMAHAWK and TOW.

5/ We are assuming marginal and average costs are declining over the range of production that one would see in this industry. This is because of the significant fixed costs (to include research and development costs) and overhead rates that must be amortized over quantity produced. Also, we assume optimal quantity to produce (minimum efficient scale) for this industry is quite large. This means plants have to be substantial in size to experience economies of scale.

6/ In most basic contracts, Economic Price Adjustment Clauses were included. The objective of this clause is that neither party shall realize economic benefit or incur economic loss by reason of abnormal economic fluctuation. This clause provides a means to adjust nominal then year dollar contract prices to final then year dollar prices using actual escalation as measured by the United States Bureau of Labor Statistics (BLS) economic indices. In the contracts we perused, the economic indices shown in Table 2 are used for determining economic price adjustments. Only Average Hourly Earnings Aircraft Engines & Engine Parts and Titanium Mill Shapes were used as proxies for engine input (e.g. labor and material) costs. This was because of their significance (30% and 39% respectively weighted) in the above Economic Price Adjustment Clause.

7/ For the explanatory variables to be significant, the t-ratio should be approximately 2.0 (-2.0) or higher (lower) and the level of significance should be .1 or lower. Conventional levels usually are .05 or lower.

8/ Running a firm-specific dummy variable (i.e. 0 for a Pratt and Whitney observation and 1 for a General Electric observation) attempts to capture variations in price due to dealing directly with General Electric or Pratt and Whitney. If this variable were significant, this implies there are effects on price that can be explained only by the fact that you are dealing with a particular firm. Intuitively, this means the Air Force does something different in its price negotiations, for example, with General Electric that it would only do with General Electric and no other firm. Therefore, the variation in price in this case would only occur for General Electric and not for Pratt and Whitney. The explanatory variables imply variations in price for both firms, not just one or the other.

Table 2

BLS Code	Index	Weight
SIC 3742	Ave. Hourly Earngs Acft Engine & Eng Parts	30%
None	Finish Steel Mill Prods.	7%
PPI 1022-0122	Cobalt	2%
PPI 1025-04	Nickel Alloy Mill Shapes	12%
PPI 1025-05	Titan. Mill Shapes	39%
SIC 3728	Ave. Hourly Earngs Acft. Equip.	10%

Where SIC = Standardized Industry Code and PPI = Producer Price Index. The above indices are prepared by the U.S. Department of Labor, Bureau of Labor Statistics and published monthly in Employment and Earnings (SIC Codes) and Producer Prices and Prices Indexes (PPI Codes).

9/See Drewes, R. W., The Air Force and the Great Engine War, Washington, D.C.: National Defense University Press, 1985, pg. 153.

10/ See Crocker, K. C. and Reynolds, K. J., "The Efficiency of Incomplete Contracts: An Empirical Analysis of Air Force Engine Procurement," 1989, Working Paper, USAF Academy, Department of Economics and Geography.

11/ This decision is also a function of the technical complexity of the product and whether or not a suitable alternative product already exists. In this case, a suitable alternative was at hand but usually this is not the case. If an alternative technically complex product is to be developed from documentation of the original product, the costs to dual source will increase.

CINC PARTICIPATION IN EVOLUTIONARY ACQUISITION OF THEIR COMMAND AND CONTROL SYSTEMS

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ABSTRACT

This report examines those considerations fundamental to Unified and Specified Command participation in an evolutionary acquisition strategy for acquiring their command and control systems and concludes with specific recommendations to institutionalize that process.

INTRODUCTION

In their reports both the 1978 and the 1987 Defense Science Board (DSB) Task Forces on Command and Control Systems Management recommend strengthening the capabilities of the Unified and Specified (U&S) Commands to upgrade their command and control systems. To do that, the 1987 DSB Task Force recommends, in addition, that the Department of Defense (DOD) "institutionalize" a process of incremental evolutionary acquisition of command-unique systems under management of the Commanders-in-Chief (CINCs) of the U&S Commands.

Evolutionary acquisition, according to the Joint Logistics Commanders, "consists of first defining the general outline of an overall system; and then sequentially defining, funding, developing, testing, fielding, supporting and evaluating increments of the system." Yet, while policies of the Department of Defense (in DOD Directive 5000.1, <u>Major and Non-Major Defense Acquisition Programs</u>, and in DOD Instruction 5000.2, <u>Defense Acquisition Program Procedures</u>) and of the Military Services (in the Joint Logistics Commanders Guidance) address the use of an evolutionary acquisition strategy, those policies ignore any consideration on how to institutionalize that strategy in direct support of the CINCs' command and control systems requirements.

POLICIES

Existing legislation circumscribes CINC participation in acquisition at all. That legislation creating the Under Secretary of Defense for Acquisition (Public Law 99-

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* This research paper reflects the opinions and views of the author and does not represent official policies of either the United States Space Command or the Department of Defense.

348) and reorganizing the Department of Defense (Public Law 99-433) clearly emphasizes the acquisition responsibilities of the Military Departments over the acquisition responsibilities of the Military Services (and thereby over any acquisition responsibilities of the CINCs). Although the 1989 Defense Management Report to the President by the Secretary of Defense addresses additional provisions (beyond those legislated) to strengthen major systems acquisition management, the report leaves the CINCs' role in acquisition to one of requirements as expressed through the Joint Requirements Oversight Council, chaired by the Vice Chairman, Joint Chiefs of Staff (JCS). Overall, the JCS Vice Chairman serves as the CINCs' spokesman not only on requirements, but on acquisition too.

In general, DOD policies on CINC participation in command and control systems acquisition are few, and on CINC participation in evolutionary acquisition, are non-existent. Current policies of the Department of Defense (in DOD Directive 5100.1, Functions of the Department of Defense and Its Major Components) and of the Joint Chiefs of Staff (in JCS Publication 0-2, Unified Action Armed Forces (UNAAF)) assign the Military Departments to provide direct support to the development and acquisition of the command and control systems of the headquarters of the U&S Commands. JCS policy further directs that the CINCs participate in the development and acquisition of their command's command and control systems and that the CINCs communicate directly with the appropriate development organization supporting the acquisition of a CINC's command and control system.

Despite an apparent lack of specific DOD policy, the CINCs participate directly in a form of evolutionary acquisition through the CINC Command and Control Initiatives Program, begun in fiscal year 1981 by the Honorable W. Graham Claytor (then the Deputy Secretary of Defense). This program provides the CINCs limited discretionary funds to support pressing needs by acquiring systems through off-the-shelf technology and through test beds.

PROBLEMS

Although the CINC Command and Control Initiatives Program is an effective method to solve short-term deficiencies, there exist problems in involving the CINCs over the long-term in command and control systems acquisition. Continuing changes in the threat, the environment, and the technology; the time-consuming requirements process; and the CINC's approach to decision-making, in sum, introduce difficulties relative to any CINC's role in command and control systems acquisition. Besides that, organizationally, the U&S Commands generally lack the skills and processes necessary to follow an evolutionary acquisition strategy.

Additionally, many CINCs have limited resources available to devote to command and control systems acquisition (resources

like funds for development and support and like skilled manpower for training and operation). These limited resources fall unequally among the CINCs, where some are more closely aligned with a Military Service or Defense Agency (Strategic Air Command or US European Command (Defense Communications Agency)); where others are not (US Southern Command); and where still others have the ability to program and acquire materiel (US Special Operations Command).

Finally, the CINCs' have ambiguous and different responsibilities, for instance, relative to interface management: national to theater, theater to tactical, and to tactical forces. The CINCs, too, have different missions (warfighting or support (US Transportation Command)), headquarters locations, and areas of responsibility.

As a result, according to Mr Edward C. Brady and Dr Stuart H. Starr (in 1989, both of the MITRE Corporation's Washington C3I Division), the CINCs tend to focus on the near-term to issues of training and readiness rather than on more far-term matters to issues like command and control systems acquisition. Consequently, the 1987 DSB Task Force recommends the use of an evolutionary acquisition strategy over the long-term as most appropriate for the CINCs in the acquisition of their command and control systems. Institutionalizing a process of incremental evolutionary acquisition of command-unique systems under the management of the CINCs meets several objectives, but requires effective management controls and certain resources.

OBJECTIVES

According to Colonel Alan D. Campen, USAF (Ret) (in 1986, a former Director of Command and Control Policy in the Office of the Secretary of Defense), there are five root causes of command and control deficiencies: (i) requirements definition and non-responsive acquisition; (ii) technology transfer and affordability; (iii) interoperability; (iv) priorities; and (v) realistic operational evaluations. The objectives in using an evolutionary acquisition strategy by the CINCs for their command and control systems acquisition address each of those five deficiencies.

In their major 1982 study on command and control systems acquisition, the Armed Forces Communications and Electronics Association (AFCEA) reports that the Military Services give inadequate attention to the real user (like the CINC) and that the most significant problem is insufficient continuing real user participation. Indeed, in the 1985 DSB Summer Study on Practical, Functional Performance Requirements, Admiral William J. Crowe, Jr., USN (then the Commander-in-Chief, US Pacific Command), states, "A mechanism to permit CINC interface with the developers is necessary to ensure that trade-offs do not result in end items which do not satisfy CINC requirements." Adds General Bernard W. Rogers,

USA (then the Commander-in-Chief, US European Command), "I ... need sufficient involvement in the development process to be aware of major design changes which could affect our capabilities."

Hence, using an evolutionary acquisition strategy provides the CINCs both a responsive acquisition process for their command and control systems requirements and a means for visibility into the technology at hand to meet their requirements. In addition, an evolutionary acquisition strategy provides the CINCs continuing insight into the acquisition's schedule and cost, that is, the acquisition's affordability. According to the President's Blue Ribbon Commission on Defense Management (the Packard Commission), that balance between requirements (or performance) and schedule and cost (or affordability) is fundamental to the ultimate success of any program.

To assure interoperability (and information security), the 1987 DSB Task Force recommends each CINC evolve the command-unique parts of his command and control system under an overarching architecture established centrally by the Department of Defense. JCS policy, as expressed in Secretary, Joint Staff, Memorandum (SM) 684-88 ("Policies and Procedures for Management of Command, Control, and Communications Systems"), explains that "a [command, control, and communications] system architecture implies an unconstrained acquisition strategy based on available and projected technology over a specific period." Two observations here merit comment.

First, without an evolutionary acquisition strategy for the CINCs' command and control systems, there exist no constraints to the U&S Commands on assessing what is realistically affordable to meet their command and control systems requirements; hence, there exists no reasonable basis infer anything useful (from the standpoint of program priorities) about architectures built from programs lacking a balance considered key by the Packard Commission. Second, implementing an overarching DOD architecture allows the CINC to focus on the priorities germane to his command's command and control system without worry about his ambiguous role relative to national, theater, and tactical interfaces.

Finally, use of an evolutionary acquisition strategy for acquiring the command and control systems of the U&S Commands allows for realistic operational evaluations without the degradations of existing systems during transition periods -- a specific concern of Admiral Crowe in 1987 when he was the Chairman, Joint Chiefs of Staff. Through such operational evaluations, the CINCs have a close hand in determining the operational utility of the systems they receive. According to the 1987 DSB Task Force, a classic example is the evolutionary development of the Joint Deployment System by the Joint Deployment Agency beginning with the 1978 Nifty Nugget exercise and costing about $60 million over the period 1980 to

1985. The results include new capabilities for the CINCs to formulate operational contingency plans and options, including force deployment options.

CONTROLS

The CINCs' interactive role in evolutionary acquisition requires degrees of initiative, management control, and responsibility. Because most of command and control systems acquisition costs are software, most of the management attention focuses on requirements, architecture, development, evaluation, integration, and support -- all procedurally intensive. For the CINC adequate procedures support resource management in two fashions: definition of relationships and control of processes.

First, according to the guidance of the Joint Logistics Commanders, "One difficult yet important area of change is the need for a much closer, interactive set of relationships among the real user (the Commander and staff who will use the system), the surrogate user (representative of the real user), the independent tester, the developer, and the supporter." Many times, without sincere, cooperative arrangements between all participants, problems sprout. For example, if the efforts of the U&S Command personnel are not carefully coordinated with the Military Services' systems engineering agencies, the Joint Logistics Commanders warn that duplication of effort and serious wastes of time and funds have the potential to occur. According to the Packard Commission, problems like deficient planning and ill-defined responsibilities are pervasive among DOD organizations. To counter that pervasive trend, CINC participation in the development of appropriate program charters and memoranda of understanding or agreement serves a real value in defining not only the relationships of the participants in the CINC's command and control systems acquisition, but the resources of the participants as well.

Second, because the objectives and measures of success for command and control systems are subjectively more difficult to define, procedural process control and standard operating procedures are mandatory in several areas (among others), in which the U&S Command staff must participate: (i) configuration management, life cycle support, and training; (ii) delineation between routine operations for peace and war verses special operations for testing and evaluating the performance of the command and control system; and (iii) use of facilities (like testbeds) and assessment tools (like simulations and models). Formal procedures manage the CINC's process of defining, evolving, and controlling requirements; formal procedures manage the process of introducing new technology, thereby minimizing any interruptions in readiness; and formal procedures manage the processes's time, which can be significant, and contribute invariably to wartime mission readiness through complementary

procedures, operations, and training.

RESOURCES

To have an interactive role in evolutionary acquisition, a CINC needs resources (that is, skilled personnel and sufficient funding) to insure continuity of management and funding and to insure adequacy of hardware, software, and personnel.

Personnel. The 1989 Defense Management Report to the President (DMR) cites the Packard Commission's emphasis on communications with users (a hallmark of evolutionary acquisition) and small, high quality staffs -- specially trained and highly motivated personnel. What steps do the CINCs need to do to adhere to the thrust of the DMR relative to their participation in command and control systems acquisition through an evolutionary acquisition strategy?

The first step is interactive leadership. The CINC develops a clear statement of his role and his needs. As General William J. Livsey, USA (in 1987, then the Commander-in-Chief, United Nations Command/Combined Forces Command and Commanding General, US Forces Korea), states, "I also took a different approach to program management within the command by having the C/J/G3 (operations) head the effort on behalf of the users." After leadership, the second step is sufficient manpower; the third step is skilled personnel.

For the CINCs to achieve their objectives through evolutionary acquisition, the 1987 DSB Task Force recommends the establishment of small architecture teams at each CINC headquarters to provide information needed for interoperability, requirements, and design of the Command's unique command and control needs. But, the experience of the U&S Commands on the CINC Command and Control Initiatives Program cautions that command and control acquisition projects can consume manpower that is uniquely and expensively trained, as well as scarce. On top of that, although staffs could be increased, the Department of Defense continues to pressure the CINCs to cut staff personnel. Nonetheless, without a technical staff, General Louis C. Menetrey, USA (in 1988, then the Commander-in-Chief, United Nations Command/Combined Forces Command and Commanding General, US Forces Korea), concludes evolutionary acquisition was a frustrating experience for his Combined Command (an experience with insight for the U&S Command).

In the 1985 DSB Summer Study on Practical, Functional Performance Requirements, General Robert Kingston, USMC (then the Commander-in-Chief, US Central Command), states, "Our ability to influence the system is often dependent upon action officer abilities, experience, and familiarity with the acquisition process," which General Rogers acknowledged then that the CINCs do not have on their staffs. Lack of prior experience with U&S Command-

level command and control systems, as well as of general technical competence, is a significant drawback to effective participation in evolutionary acquisition by the personnel of the U&S Commands. Consequently, the CINC requires a small and technically well-qualified group which not only can represent the *CINC's* situation to the other organizations participating in the evolutionary acquisition of the command-unique command and control systems, but can remain stable long enough to prevent wide swings of opinion.

A fact of life, too, is the need for the CINCs to have continuous technical and system engineering support at their headquarters; for as the Packard Commission observes rather ironically, "Members of headquarters staff are rated as least likely to provide needed support to other team members." Nonetheless, besides dedicated technical and system engineering support, other resources potentially available to the CINCs' staffs include users groups like the WWMCCS (Worldwide Military Command and Control System) Technical Users Group, for example, which provides a medium to exchange information between users and others.

Funding. For the CINCs to have an appropriate role in the evolutionary acquisition of their command and control systems, the CINCs require funding, both current and out-year. This is a conclusion of many -- including both the 1978 and the 1987 DSB Task Forces, the 1982 AFCEA Study Team, and in 1979, both Deputy Secretary of Defense Claytor and General David C. Jones, USAF (then the Chairman, Joint Chiefs of Staff (CJCS)). The anticipated purpose of these funds is to adapt, modernize, and maintain the CINCs' command and control systems to fit the unique needs of the U&S Command, in particular, to permit local software and hardware *experimentation*, closely coupled with a central configuration management facility. Use of these funds also anticipates including short-term contract support, operational test, hardware purchases, and travel. Based on a level-of-effort philosophy, the total amount recommended by those cited above is about ten percent per annum of the invested value of systems or (in 1979) $1 million to $10 million per CINC.

CONCLUSIONS

According to the 1982 AFCEA Study Team, use of an evolutionary acquisition strategy is spotty and not well understood. Nevertheless, the 1987 DSB Task Force recommends that "DoD should institutionalize this process of incremental evolutionary acquisition of command-unique systems under CINC management and with Service support of the required technical infrastructure."

The essential conclusions that the AFCEA Study Team recommends in its report are the basics to "institutionalize this process" as recommended by the 1987 DSB Task Force. As adapted for here, these conclusions are: (i) alter the roles of the participants, (ii) strengthen and assure continuous CINC

involvement, (iii) provide the CINCs with the resources (people, tools, funds, and facilities), (iv) provide for joint CINC/tester/developer test and evaluation (especially for CINC determination of operational utility), and (v) recognize the changed nature of training and logistics (affecting, for example, configuration and integration management, which are necessary to assure interoperability).

Yet, going back more than a decade, when the Honorable Charles W. Duncan, Jr. (in September 1978, then the Deputy Secretary of Defense) asked Dr William J. Perry (then the Under Secretary of Defense for Research and Engineering) and General Jones to establish mechanisms for increased command participation in command and control systems acquisition, not much exists to show what mechanisms have ever been established beyond those policies indicated above. Although answers to specific resourcing questions remain elusive (from where do personnel and funding come?), the following specific recommendations indicate what mechanisms could be established to institutionalize that process.

Acquisition Policy. Revise DOD Directive 5000.1, Major and Non-Major Defense Acquisition Programs, (and concomitantly DOD Instruction 5000.2, Defense Acquisition Program Procedures) to conform to the limited existing DOD policies on CINC participation in command and control systems acquisition by requiring the Military Departments and Defense Agencies to: (i) obtain CINC comments and reviews on requirements and programs affecting their command and control systems, and (ii) involve the U&S Command by incorporating the appropriate portions of the Joint Logistics Commanders Guidance for the Use of an Evolutionary Acquisition (EA) Strategy in Acquiring Command and Control (C2) Systems.

Test and Evaluation. Revise DOD Directive 5000.3, Test and Evaluation (especially paragraph C.9); JCS Publication 0-2, Unified Action Armed Forces (UNAAF) (Section IX); and CJCS Memorandum of Policy (MOP) Number 50, "Command, Control, and Communications Systems Master Plans, Assessments, and Evaluation," (Chapter IV) to reflect the role of the CINCs in an evolutionary acquisition strategy. The paragraph in DOD Directive 5000.3 on Joint Test and Evaluation has two categories (Joint Development Test and Evaluation and Joint Operational Test and Evaluation) but each fails to consider the unique aspects of evolutionary acquisition, especially as it pertains to the CINCs' world. The paragraph in JCS Publication 0-2 on Operational Testing and Evaluation furthermore fails to address Joint Test and Evaluation. Lastly, the paragraph in CJCS MOP 50 on Operational and Technical Tests not only fails to consider any aspects of evolutionary acquisition, but fails to consider any aspects of test and evaluation as reflected in DOD Directive 5000.3.

Configuration Management. Revise DOD Directive 5000.29,

Management of Computer Resources in Major Defense Systems, (especially for paragraph VI.C) to apply to the CINCs as appropriate for their participation in an evolutionary acquisition strategy for acquiring command and control systems.

Personnel. Revise DOD Directive 1320.5, Assignment to Joint Tours of Duty, (paragraph D.2.e.) so as not to waive some acquisition personnel with the requisite command and control skills such that those personnel would be available to serve in joint tours in the U&S Commands.

Training. Revise CJCS MOP 26, "Joint Training Program," (paragraph 8a) to add command and control systems acquisition to the U&S Command's Joint Mission Essential Task List. Concomitantly, encourage the Defense Systems Management College to provide a short course for those U&S Command personnel selected to be part of the CINC's command and control systems acquisition team.

Requirements Validation. Revise JCS SM-684-88, "Policies and Procedures for Management of Command, Control, and Communications Systems," (and concomitantly CJCS MOP 50, "Command, Control, and Communications Systems Master Plans, Assessments, and Evaluation") to recognize the special character of evolutionary acquisition as relevant to the U&S Commands. (Although complementary and functionally interrelated to CJCS MOP 50, SM-684-88 retains policy guidance on C3 requirements validation and acquisition.) Three suggested revisions follow. (i) The Command, Control, and Communications System Planning Framework (Figure II-2) shows that the system acquisition process derives from detailed architectures via implementation plans and the Planning, Programming, and Budgeting System. But since architectures are unconstrained (by definition in SM-684-88), there is a philosophical disconnect in implementing a process based on an evolutionary acquisition strategy. (ii) As SM-684-88 establishes the requirement for a fielding plan as a basis for examining interoperability issues, the concept of fielding plans, *per se*, needs adjusting to address use of an evolutionary acquisition strategy. (iii) SM-684-88 (Appendix D, paragraphs 1.a.(3)(b) and (c)) requires that development of either a preliminary estimate or a technical analysis/cost estimate addresses a series of considerations. These considerations need to mesh with the areas (requiring special consideration when using evolutionary acquisition) listed in the Joint Logistics Commanders Guidance for the Use of an Evolutionary Acquisition (EA) Strategy in Acquiring Command and Control (C2) Systems (Section 5).

Program Management. Revise the Joint Logistics Commanders' Guide for the Management of Joint Service Programs to recognize the process of incremental evolutionary acquisition of command-unique systems under the management of the CINCs. First, involve the CINC and the U&S Command, as

appropriate, in the plans and reports associated with the management of: (i) Multiservice Systems, Programs, and Projects (Appendix A); (ii) Multiservice Operational Test and Evaluation and Joint Test and Evaluation (Appendix C); and (iii) Joint Integrated Logistics Support Plans (Appendix D). Second, link this revision to the components of a total quality management (TQM) program (a program like one discussed, for example, in Mr William E. Perry's January 1990 Signal article, "Improving Software Development"). This supports the Department of Defense's policy (according to Mr Jack C. Strickland, in 1989 the Director for Industrial Productivity and Quality, Office of the Assistant Secretary of Defense (Production and Logistics)) to leverage the benefits of TQM over a wide range of DOD initiatives of value to the acquisition process (as "this process of incremental evolutionary acquisition ..." would be). And finally,

Ethics. Both the President (in his March 1990 National Security Strategy of the United States) and the Secretary of Defense (in his June 1989 Defense Management Report to the President) echo the Packard Commission in calling for "an environment where official standards of conduct are well understood, broadly observed, and vigorously enforced." If the CINCs' personnel are to be given a substantive role in acquisition through the use of an evolutionary acquisition strategy for acquiring their command and control systems, then the U&S Commands have to institute a periodic system of ethics training specifically related to acquisition.

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THE REQUIREMENTS PROCESS FOR THE ACQUISITION OF COMMAND AND CONTROL SYSTEMS: NEEDS, SHORTFALLS, AND CHALLENGES

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ABSTRACT

Over the past decade, there has been a growing appreciation of the importance of the requirements process in the effective acquisition of command and control (C^2) systems. The goal of this paper is to assess critically the nature of the requirements process for these systems and to suggest options to ameliorate many of its deficiencies. To establish a context for the assessment, a trend analysis is performed of the key forces that influence C^2 system requirements: geopolitical, national security policy, force structure and operations, systems and technology, resources, and institutional factors. Based on this analysis, five attributes are *identified and discussed against* which alternative requirements processes can be evaluated: the ability to cope with change, the extent to which it supports communication among all the participants in the process, the completeness and the consistency of measures of merit (MoMs) employed in the process, the type, credibility, and consistency of tools used, and the ability to deal with the unique characteristics of C^2 systems. Using these attributes, the requirements processes associated with traditional acquisition and evolutionary acquisition are described and assessed. The assessment reveals that the requirements process employed in the traditional acquisition of C^2 systems is gravely flawed with respect to each of the five attributes. Conversely, evolutionary acquisition is inherently capable of satisfying each of the attributes. However, there are shortfalls and issues in each attribute area that pose serious challenges for the evolutionary acquisition community. Three specific issues are identified and analyzed further: institutionalization of the evolutionary acquisition process, development and accreditation of a mix of tools, and selection of appropriate contractual mechanisms.

INTRODUCTION

In a recent interview, Don Hicks, former Under Secretary of Defense for Research and Engineering (USDRE) observed "There is an unfortunate lack of communication...between the builder, who understands the cost and risk, and the military user who wants everything...[As a result] requirements are written very often without consideration of the cost and risk that evolve from them." [1] In a parallel interview, Lt. Gen Glenn Kent (USAF, ret.), former Director, Weapons System Evaluation Group, summarized his views on the requirements process more tersely: "It is an absolutely pernicious venture."[2] These views tend to be representative of the dismay that many experienced participants in the acquisition of military systems express about the requirements process and the manner in which it has been implemented traditionally.

The goal of this paper is to assess critically the nature of the requirements process for the acquisition of C^2 systems and to suggest options to ameliorate many of its deficiencies. To achieve that goal, three inter-related objectives have been established. First, the paper derives the attributes that any viable requirements process must possess. Second, it assesses the extent to which alternative acquisition strategies for C^2 systems manifest these attributes. Finally, it identifies and discusses residual challenges that must be addressed if the requirements process for C^2 systems is to be improved substantively.

The scope of the paper is restricted in two significant dimensions. First, it focuses only on the acquisition of the C^2 systems that

commanders and their staffs employ to exercise operational direction of military forces in the performance of their assigned missions. However, many of the conclusions of this analysis are germane to the acquisition of complex weapon systems because several weapon systems are beginning to assume many of the key characteristics of C^2 systems (e.g., they are becoming more software intensive and their effectiveness is critically dependent on the performance of distributed teams of human operators). In addition, attention is limited to only two acquisition strategies: the traditional ("waterfall") acquisition approach and evolutionary acquisition,with primary emphasis on the latter approach.

To achieve these objectives, the paper is organized into three main sections. First, to clarify the nature of the problem, a trend analysis is performed for the factors that drive C^2 requirements. Based upon this analysis, a set of attributes is derived that a successful requirements process must manifest. Second, two alternative acquisition philosophies --traditional acquisition and evolutionary acquisition-- are described and analyzed. Each acquisition philosophy is compared to the set of attributes needed for an effective requirements process and shortfalls are identified. Finally, three residual areas of concern are explored in greater depth. These include the institutional process by which requirements are formulated and validated, the sets of tools that are needed to support the requirements process, and the contractual vehicles that are appropriate to respond to the nature of C^2 requirements.

NATURE OF THE PROBLEM

In Joint Chiefs of Staff (JCS) Publication 1, a military requirement is defined as "an established need justifying the timely acquisition of resources to achieve a capability to accomplish approved military objectives, missions, and tasks". Implicit in this definition is the concept of *balance* among three factors: the mission to be supported, the technical performance of the system, and the resources (e.g., funds, schedule) required to develop and deploy the system. As noted by former USDRE Hicks[1], we have paid severe penalties when these factors are not in balance.

Trend Analysis. To gain insight into the difficulty in achieving this balance, consider the major forces that must be weighed to strike this balance. In order to understand the mission that the system is to support, it is necessary to understand the relevant geopolitical forces and associated national security policy. To appreciate the needed technical capabilities, it is necessary to understand the associated forces (e.g., structure, concepts of operation), systems, and technology. Finally, to appreciate resource constraints it is important to be cognizant of trends in funding and personnel, as well as institutional limitations and initiatives (e.g., the Defense Management Review (DMR)[3]). These forces are depicted schematically in Figure 1.

A brief, high level analysis of these factors serves to accomplish several objectives. First, it clarifies the attributes that must be satisfied if the requirements process is to be successful. Second, it serves to identify many of the substantive characteristics that C^2 systems must possess if they are to reflect user needs adequately.

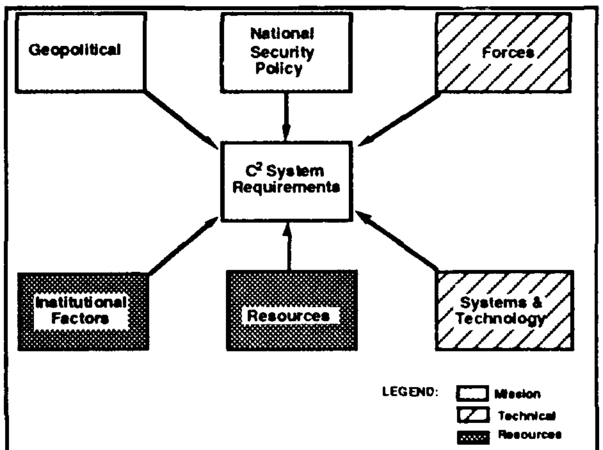


FIGURE 1. Key Forces Influencing C^2 System Requirements

• *Geopolitical.* Geopolitical and national security policy factors fall within the domain of high level decision makers. Currently, these factors are undergoing changes that are more far-reaching than any that have been experienced since the conclusion of World War II. These changes are most apparent in two interrelated trends: the receding of the threat posed by the Warsaw Treaty Organization (WTO) and the emergence of an increasingly multi-polar world. The ramifications of these changes on C^2 requirements are likely to be considerable. For example, many of the survivability features of our C^2 systems have been driven by the Radio Electronic Combat (REC) capabilities of the WTO (e.g., its proliferation of high powered, sophisticated jammers). An easing of this threat may portend a relaxation of these requirements. Conversely, the emergence of more threatening elements of the Third World are posing a broad new spectrum of C^2 requirements. As an illustration, the military capabilities of Iraq have highlighted our needs for improved C^2 to support anti-tactical ballistic missile defenses (e.g., enhanced alerting, cueing) and enhanced hardening of C^2 systems against chemical and biological agents.

• *National Security Policy.* In response to these geopolitical trends, the U.S. is re-evaluating its national security policy. One of the most significant changes in national security policy involves the increasing interest in operations at the low end of the conflict spectrum (i.e., ad hoc contingency operations, counter-narcotics operations). In recent years, there have been a significant number of military missions undertaken by ad hoc joint task forces with very limited planning windows (e.g., Operation Desert Shield/Storm in Saudi Arabia, Operation Just Cause in Panama, Operation Urgent Fury in Grenada). Although the scale and intensity of these operation have varied dramatically, each of them was hindered substantially by limited in-theater C^2 infrastructure and by transportation constraints. This suggests that there will be a heavy premium on future C^2 systems that are more readily transportable (e.g., lower weight, smaller volume), are designed to be interoperable with other Service and coalition systems (e.g., employ standards that permit flexible internetting of systems and sharing of data), are more immune to environmental extremes (e.g., impervious to dust and temperature extremes), and are more strongly dependent on space-based assets to support a myriad of globally available resources (e.g., communications, sensors, navigation, meteorological assets).

Similarly, the increased interest in counter-narcotics operations poses new, challenging problems for the C^2 community. Since the Department of Defense (DOD) is playing a supporting role in this operations, there is an emerging requirement for it to field communications systems that are interoperable with those of U.S. Law Enforcement Agencies and Host Nations in the Andean Ridge.

• *Forces.* Factors relating to force structure and force operations fall within the domain of the military user community. In response to changing national security policy and resource constraints, a significant change in force structure is envisioned over the coming decade. The most important of those changes are projected to occur in the size and basing of U.S. forces.

In his August 2nd speech in Aspen, Colorado,[4] President Bush observed that within five years, the nation's 2.1 million-member military could be cut by 500,000. Since the numbers of many deployed C^2 systems are directly proportional to the size of U.S. forces, a corresponding decrease in production levels of these systems can be anticipated. Consistent with these changes, a significant drawdown of U.S. forces from forward bases (e.g., Europe, Philippines, Korea) is anticipated. Consequently, since U.S. forces may have to be re-deployed, world-wide, with little advanced warning, it suggests the need for an improved infrastructure to support deployment and smaller, lighter C^2 systems.

In the area of force operations, changes in national security policy and force structure are prompting fundamental changes in concepts of operation. For example, the force drawdowns in Europe are stimulating NATO planners to reconfigure forces to field fewer, more mobile, international corps'. These changes imply the need for U.S. C^2 systems that are more interoperable with those of our allies and more mobile systems that can support this revised concept of warfare.

• *Systems and Technology*. Factors relating to systems and technology fall within the domain of systems engineers, testers and evaluators, and technologists. In the area of systems, the mix of hardware and software in C^2 systems is changing substantively. Where once the cost of these systems was dominated by hardware costs, examples are emerging where up to 80 percent of system life cycle costs are attributable to software. In addition the pressures arising from resource constraints are prompting the community to re-evaluate its prior insistence on developing and deploying military-unique systems. This is manifested in two interrelated ways. First, it is perceived that the military could save funds by taking advantage of the sophisticated civilian C^2 infrastructure that is being fielded by friendly nations (e.g., telecommunications, air traffic control). However, this requires military systems that are adequately interoperable with these in-theater resources and means to manage these resources that are available in times of conflict or crisis. Second, it is understood that Commercial-off-the-Shelf (COTS) equipments are emerging in the area of information systems (e.g., personal computers) that could provide timely, inexpensive solutions to many of the needs of the C^2 community. However, if the military is to be able to take advantage of these assets, appropriate standards must be adopted and implemented.

The enhancements in military and civilian C^2 systems is being fueled by a revolution in microelectronics. As an illustration, recent trends in integrated circuits reveal dramatic increases in chip speed and density with corresponding decreases in chip size and cost. This "technology pull" poses opportunities and challenges for the requirements process. First, it spawns informations systems every two or three years that are improving rapidly in nearly every measure of merit (e.g., performance, cost, weight, size). Conversely, it is prompting the rapid obsolescence of systems as it becomes increasingly difficult to procure spare parts or to maintain equipment that is over a decade old.

• *Resources*. Factors relating to resource constraints fall within the domain of programmatic analysts, support personnel, and trainers. The predominant trend in this area is the decrease in outlays for national defense that is anticipated for the 1990's. This is a consequence of the perceived decrease in the threat posed by the WTO and the economic pressures arising from the nation's debt and balance-of-trade deficits. These trends will be reflected in the reduction of major new C^2 systems starts and efforts to generate economies of scale. As an illustration of the latter quest, OSD has recently begun a Corporate Information Management (CIM) initiative that seeks substantial savings by reducing the number of redundant, incompatible management information systems that support DOD's administrative needs[5]. Additional constraints are anticipated in the area of manpower limitations. The reductions in military manpower will be felt within the acquisition and operational communities. Consequently, C^2 systems will have to be developed and procured using substantially fewer personnel; and fielded systems will have to be configured to require fewer operators, maintainers, and trainers. In addition, demographic trends that portend greater diversity in the workforce in the areas of ethnic background and education will have to be reflected in the complexity and human machine interface of C^2 systems.

• *Institutional Factors*. Finally, the requirements process will be strongly shaped by recent institutional trends. These include the Goldwater-Nichols Reorganization Act of 1986 which sought to give the Unified and

Specified Commanders-in-Chief (U&S CINCs) a stronger voice in the acquisition process, and the on-going DMR. As a consequence of this latter initiative, there is extreme pressure on the acquisition community to adopt new strategies that will lead to reductions in costs, personnel levels, schedules, and risks. In particular, the acquisition community is being strongly encouraged to take advantage of COTS equipment, procure Non-Developmental Items (NDIs), employ evolutionary acquisition techniques more widely, and adopt Total Quality Management (TQM) principles and processes.

Attributes of a Viable Requirements Process. The trend analysis of the factors that drive C^2 requirements serves to highlight five attributes that a viable requirements process must accommodate: change, communication, MoMs, tools, and C^2 system uniqueness.

• *Change.* It must be recognized that most of the critical factors that drive C^2 requirements -- geopolitical, force structure, technology -- are changing on a timescale that is short with respect to the normal C^2 system acquisition process. Although it may be argued that certain of these changes are anomalous (e.g., the disintegration of the WTO as we transition from the Cold War period), it is still likely that abrupt changes in many of these factors will occur well into the decade of the 90's. Consequently, it is critical that a requirements process be formulated and implemented that anticipates and accommodates these changes. This implies that the requirements process must be performed iteratively, throughout the lifecycle of a system, to reflect "lessons learned" from prior efforts and to track the changes that affect the system.

• *Communication.* The analysis reveals that there are many heterogeneous participants who are involved in the factors that drive C^2 requirements (e.g., high level decision makers, operational personnel, systems engineers, technologists, programmatic personnel, test and evaluation personnel, support personnel, training personnel). If C^2 requirements are to manifest the needed balance among missions, technical capabilities, and resources, this full set of participants must contribute their unique expertise and points of view and be able to communicate them effectively to other participants in the requirements process. Note that this need goes will beyond the frequently expressed desire to have the "user and developer" communicate effectively during the requirements process. This need to communicate effectively must overcome a host of barriers that have traditionally obstructed the process (e.g., cultural biases, lack of a unifying framework, absence of a common vocabulary, participants operating outside their domain of expertise).

• *Measures of Merit.* To help overcome these obstacles to communications, it is important to formulate a self-consistent hierarchy of MoMs. This entails the development of MoMs that characterize the domains of interest of key participants (including policy objectives, mission effectiveness, operational suitability, system performance, technology risk, and programmatic factors (e.g., cost, schedule)). These MoMs should be selected to highlight all critical issues and tradeoffs, to facilitate the linkage across key levels of the hierarchy (e.g., to relate technical performance to mission effectiveness), and to establish an objective basis for specifying the system and defining needed developmental and operational tests.

• *Tools.* The process requires a mix of accredited tools that can be used to evaluate the MoMs at each level of the hierarchy. These tools should serve to help participants understand their domains of interest (by performing sensitivity analyses, as appropriate) and communicate their findings to other participants in the process. To gain maximum benefit from these requirements tools, a plan should be developed to guide their growth and evaluation so that they can meet the needs of the acquisition community in later stages of the process (e.g., development, T&E, training).

• *C^2 System Uniqueness.* The requirements process must respond to the unique character

of C^2 systems themselves. One attribute that emerged repeatedly in the trend analysis was the need for interoperability of C^2 systems with those of other Services, nations, non-DOD organizations (e.g., law enforcement agencies), and civil systems. In addition, the analysis revealed that C^2 requirements process must be prepared to deal with systems that have high software content, involve human operators as integral elements, and are prone to rapid obsolescence due to the nature of its electronic subsystems.

ANALYSES OF ACQUISITION STRATEGIES

The attributes of a viable requirements process provide a standard against which one may evaluate two alternative acquisition strategies: traditional acquisition (the "waterfall" model) and evolutionary acquisition. Primary emphasis is placed on describing and assessing evolutionary acquisition.

Traditional Acquisition. The traditional acquisition strategy is depicted schematically in Figure 2. This approach typically starts with the Concepts-Based Requirements Process which develops a system specification, generates a Request for Proposal (RFP), selects a contractor, and develops a system. In this strategy, the requirements process is viewed as the "front end" of the acquisition.

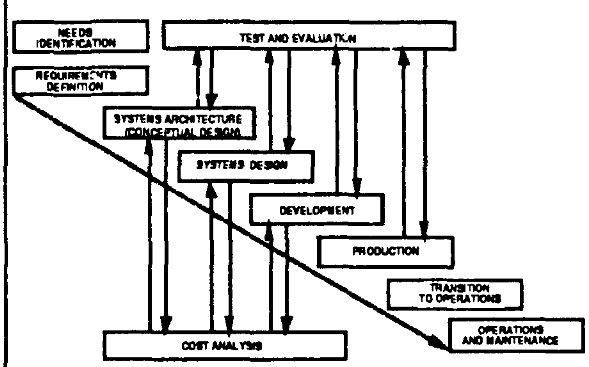


FIGURE 2. The Traditional Acquisition Approach

Although it is widely recognized that this approach has been generally ineffective in acquiring C^2 systems, some members of the acquisition community believe that the approach can be used successfully if two principles are adhered to. It is maintained that the traditional process will work better if more time is spent specifying requirements up front. In addition, it is claimed that success depends on the ability to minimize changes to the system (i.e., "freeze" design and specifications early). While adherence to these principles would serve to focus and stabilize a program, they fail to respond to the fundamental realities of C^2 system acquisition cited above.

- *Change.* This approach fails to acknowledge that change must be accommodated by the process to respond to variability in the factors that drive requirements. For example, it is not unusual for systems that emerge from this process to feature technically obsolescent sub-systems.

- *Communication.* This approach fails to foster adequate interaction among the communities that must participate in the requirements process. For example, it limits operational user involvement during concept formulation and systems development and maintains an "arms length" relationship between the government and the contractor during development.

- *Measures of Merit.* Traditional acquisition tends to limit attention to a small subset of the required MoMs. Emphasis is placed on measures of system performance (e.g., capacity, jam resistance) and measures of operational suitability (e.g., reliability, maintainability). As a consequence, it typically bases system T&E on meeting specifications versus enhancing mission effectiveness.

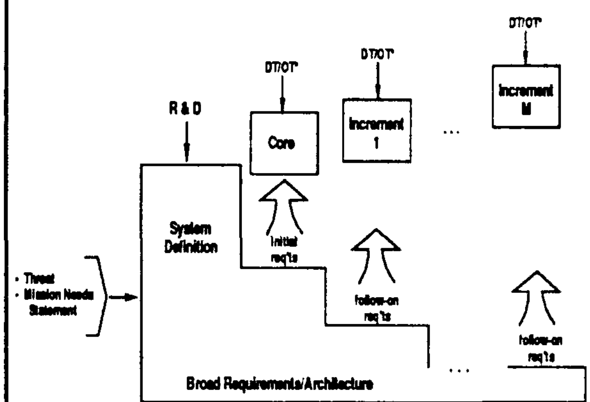
- *Tools.* The traditional approach frequently fails to develop an adequate set of tools to support tradeoffs among mission effectiveness, technical performance, and resources. Many of the tools employed do not treat essential elements of the problem adequately (e.g., the role of the human; the

impact of system performance on force effectiveness). In addition, there is little attempt made to accredit many of these tools, to mature and refine them as the system is being developed, or to use them in carefully structured sensitivity analyses[6].

• *C^2 System Uniqueness.* The traditional approach has generally failed to respond to the unique attributes of C^2 systems. The most notable failure has been its inability to develop systems that are interoperable. Program managers using the traditional approach tend to view interoperability as a low priority, ancillary feature and generally fail to make it integral to a system's design. In addition, this approach has consistently failed to develop complex system software on time or within cost, or to develop key features (e.g., human machine interface) that satisfy the user's needs.

Evolutionary Acquisition. In recognition of the difficulties associated with the traditional acquisition process, the concept of evolutionary acquisition of C^2 systems has emerged from several Blue Ribbon Panels[7,8,9]. In this acquisition philosophy, the requirements process is no longer viewed as the "up front" segment of an acquisition. It becomes a continuing process that pervades the life cycle of the system in question. To implement that philosophy, the following strategy is employed.

An initial increment is acquired that includes a well-defined "core" system capability that is fielded quickly, a broad requirements statement, and an open, layered architecture to guide the evolution of the system. This is followed by subsequent increments that are defined interactively with operational users and implemented sequentially. These increments can be in the form of block upgrades or incremental releases of software. The requirements for these increments are driven by key factors (normally time varying) that emerge as the system evolves (e.g., feedback from the operational user, evaluation of the hardware/software, and opportunities afforded by new technology). This strategy is depicted schematically in Figure 3.



*Developmental Testing/Operational Testing (DT/OT)

FIGURE 3. The Evolutionary Acquisition Strategy

In this strategy, the accommodation of change is achieved through software and the judicious insertion of hardware. The cost of change can be reduced in several ways: by architectural choice (e.g., use of the ISO OSI model); by adoption of standards that are used widely in the commercial community (i.e., to facilitate the insertion of COTS equipment); by implementing a modular design (e.g., isolation of data base functions); and by employing sound development tools and techniques (e.g., structured programming).

The evolutionary approach involves three basic components. As a foundation, it requires an *interactive requirements capability* (or testbed). The key is a rapid prototyping design capability that has several attributes. It is done with "mirrors," in that it is not necessary to develop and use operational software or hardware. The prototypes that are developed in this testbed environment can encompass a wide spectrum of complexity, ranging from a simple mockup of a man-machine interface to an extensive system consisting of commercial computers, displays, and software. The common thread is short development time, minimized cost, and the opportunity for users to visualize a given system or alternative system concepts.

Currently, it is envisioned that a reasonably complex C^2 system would begin the acquisition process by fabricating and employing a Rapid Requirements Definition Capability (RRDC) to develop the system concept and core requirements. Subsequently the RRDC would be augmented so that it can serve as an off-line test facility (or System Design and Test Facility [SDTF]). These facilities would be updated to reflect the evolution of the system and to help develop the requirements for future increments of the system. It thus provides the framework for a constructive dialogue between the user and the developer.

Second, the evolutionary approach involves the use of an *open, layered architecture* that modularizes industry standard or non-proprietary functional and equipment subsystems. The modularization should accommodate the differing time constants for the system elements. This should allow for changes in display formats and decision templates, at will; changes in sub-system technology, consistent with the on-going revolution in microelectronics; the expected technological obsolescence of hardware (e.g., several years); and the expected obsolescence of system software and application software (e.g., many years).

Finally the evolutionary approach entails *incremental implementation and enhancement*. As noted above, the first increment involves the system architecture and partial system capabilities. Additional increments serve to add or modernize system functions. This approach should prove more amenable to coding, testing, and implementation than the traditional acquisition approach.

By assessing the evolutionary approach against the desired attributes of the requirements process, it is possible to identify its strengths and residual deficiencies.

• *Change*. The evolutionary approach has been configured to anticipate and treat change explicitly. This is accomplished through several interrelated mechanisms. It decomposes the system into increments whose specific requirements are developed iteratively to reflect changes in key factors (e.g., technology advances, feedback from users of earlier versions of the system). In addition, it develops a modular, open architecture that facilitates the insertion of new hardware and software subsystems. However, there are several unresolved issues in this area. It is proving difficult to establish program plans (e.g., technical features and schedules for new block increments) that successfully balance technical risk and user demand. For example, in preliminary applications of a variant of the evolutionary approach (e.g., World Wide Military C^2 System Information System (WIS)), problems arose when the program was partitioned into increments with overly ambitious schedules and technical features. Similarly, the need to anticipate and respond to changes poses difficult contractual problems. A naive use of firm fixed price (FFP) contracts poses grave risks in a volatile program while cost plus fixed fee (CPFF) contracts may make it difficult to control costs.

• *Communication*. Through its heavy emphasis on rapid prototypes and testbeds, the evolutionary approach has been designed to enhance the dialogue between the user and the developer. However, there is a need for additional mechanisms to broaden the dialogue with other key participants in the process (e.g., T&E community, programmatic personnel).

• *Measures of Merit*. The evolutionary approach has taken substantive steps to broaden the MoMs it employs beyond the classic measures of system performance and operational suitability. Through the expanded use of controlled experiments with human operators using rapid prototypes it is able to perform more complete quantitative assessments of functional performance and, in selected instances, mission effectiveness. Residual deficiencies are still being experienced in developing overall measures of mission effectiveness and reliable programmatic estimates (e.g., program cost and schedule).

• *Tools*. Evolutionary acquisition has significantly broadened the set of tools employed to develop requirements through the innovative use of rapid prototyping and testbeds. However, there are still significant voids in existing sets of tools. It is recognized that additional thought must be given to verifying, validating, and accrediting (VVA) prototypes and testbeds. Although prototypes and testbeds are key tools, they are in themselves inadequate, and must be complemented and orchestrated with a broader set of tools (e.g., fast time simulation, exercises) through common data bases and assumptions. In addition, the evolving nature of the system implies that resources must be allocated to evolve the tool sets so that they can continue to support acquisition and operation throughout the full life cycle of the system. Finally, the absence of an extensive experience base in evolutionary acquisition has hindered the development of credible programmatic tools.

• *C^2 System Uniqueness*. The extensive use of rapid prototypes and testbeds makes the human operator the focus of evolutionary acquisition. The use of these tools has also tended to give enhanced visibility to the critical problem of interoperability. In addition, the modular architectures employed in evolutionary acquisitions are configured to reflect the high software content of C^2 systems and the opportunities (and risks) posed by the revolution in microelectronics. However, the problem of software development is still largely a "black art" and there is a need for more extensive standards to facilitate the timely insertion of new technology.

KEY RESIDUAL CHALLENGES

Among the challenges cited for evolutionary acquisition in the prior section, three are particularly germane to the problem of requirements formulation: institutional mechanisms that define the roles for participants in the process and enhance communication among them; development and orchestration of needed tools; and selection of appropriate contractual mechanisms that allow for needed changes as the system evolves. The following discussion describes recent advances in each area and identifies residual challenges.

Institutional Mechanisms. The evolutionary acquisition approach implies a modification in the traditional roles of the system user, developer, and independent tester in the requirements and acquisition processes. A number of institutional activities are underway in the U.S. to stimulate the needed changes to the requirements process[10]. For example, in order to identify operational requirements the U&S CINCs have been asked to submit brief (≤ 4 page), non-technical Requirements Submissions (RSs) for each perceived significant shortfall in command and control. The RS is to document the deficiency, explain how it adversely affects the commander's concept of operations, and prioritize the requirement. In this new process, the Joint Staff is to make a validation determination of the RS within ninety days. If the RS is perceived to be a valid operational requirement, detailed technical analyses/cost estimates (TA/CEs) are to be performed by technical and programmatic analysts within the appropriate Service/Defense Agency. Based upon the results of these analyses and estimates, a decision will be made as to whether a military requirement for the program exists. If the decision is affirmative, the analytic package (with its costed, preferred option) is designated a Required Operational Capability (ROC) and a Mission Needs Statement (MNS) is sent to the Defense Acquisition Executive to begin acquisition.

In order to provide broader, high-level review of the requirements process, a Joint Requirements Oversight Council (JROC), comprised of the Vice Chiefs of the Services (or their equivalents), has been formed. In the recent DMR report[3], the JROC was tasked "to review all deficiencies that may necessitate development of major systems. . . ." in order to validate, prioritize, and approve mission needs statements.

These initiatives serve to institutionalize several critical needs in the requirements

process. First, they compel the various communities involved (e.g., operational, technical, programmatic, high-level decision maker) to formulate and validate requirements in the domain in which they are expert. Second, this revised process serves to enhance communications among the affected communities. There are, however, several residual challenges associated with institutional mechanisms which remain to be resolved. First, the changes cited above are complex and far-reaching. Thus, it must be anticipated that it will take a significant period of time for the various communities involved to overcome the cultural barriers associated with changing roles and relationships. Second, comparable institutional changes have not yet been implemented for another key participant in the process -- the T&E community. A C^3I Implementation Plan is being developed in the Office of the Secretary of Defense that seeks to define the methodology and tools that the T&E community should bring to bear in the acquisition process[11]. The draft plan specifies a significant role for the T&E community to play in the requirements process. However, a recent assessment of the draft plan has recommended that it be reconfigured to stress the unique aspects of C^3I systems and to provide explicitly for the need to tailor the approach to reflect the characteristics of specific systems[12]. Thus, in the interim, there continues to be considerable ambiguity about the role that the T&E community should play in the C^2 system requirements process. Finally, as one facet of the DMR, DOD is revising the 5000-series of directives that govern the acquisition process. These revisions will undoubtedly have a major impact on the roles and relationships of participants in the requirements process.

In parallel with these developments, NATO is manifesting considerable interest in employing evolutionary acquisition principles to procure information systems. A prototype activity is envisioned shortly as a means of assessing the viability of the approach and identifying institutional changes that would be required to implement the approach more broadly[13].

Tools. At present, there is little consensus on the methodologies and tools that should be employed to support the formulation and refinement of requirements in evolutionary acquisition. However, consistent with the definition of the phrase "military requirement," it is clear that it will be necessary to conduct coordinated analyses that relate and encompass technical performance and mission effectiveness, design trade-offs, and programmatic factors (e.g., cost, schedule).

• *Evaluation.* In the area of evaluation tools, a spectrum of resources is required, subsuming expert judgement, computer models, laboratory activities (e.g., rapid prototypes, testbeds), and field activities. (See table I.) Consistent with this progression, it can be seen in table I that the tools are progressively more expensive to build and employ, more time consuming to prepare and use, less flexible to use, and more difficult to use to replicate test conditions. Conversely, the data from the tools are more realistic as one goes from simple models to the results of actual field experience. These trends suggest that a self-consistent set of tools be developed and employed to trade off among these factors.

TABLE 1. Attributes of Candidate Evaluation Tools

Category	Tool	Resource Requirements	Lead Time	Replicable	Degree of Flexibility	Degree of Realism
Expert Judgement	Decision Analysis	Low	Weeks	Yes	Very High	Quite Low
Computer Models	Theater Models	Moderate	6 Months to a Year			
	Mission Area Models					Low
	C^3 System Models					Moderate
Laboratory Activities	Rapid Prototypes			With Some Difficulty	High	
	Testbeds	Moderate to-High	Several Years		Moderate	
Field Activities	Field Tests	High	2 to [illegible] Years	With Much Difficulty	Very Limited	A Fair Amount
	Exercises			No	Almost None	A Great Deal But Still Deficient
	Operations Experience	Very High	-		None	Realistic, for Given Conditions

Expert judgement tools (e,g, decision analytic techniques[14]) are particularly valuable in eliciting the perceived requirements and priorities of operational personnel. However, the validity of these findings is

dependent upon the credibility and operational understanding of the participants and the skill of the facilitator that leads the deliberations.

Computer models provide a means to derive more quantitative answers to questions of C^2 system technical performance and contribution to mission effectiveness. However, recent workshops have raised several residual challenges that must be met if these tools are to be used confidently in deriving C^2 system requirements. First, it is recognized that these tools tend to be weakest in these areas that are most critical to understanding C^2 systems (i.e., cognitive factors, human factors[15]). In addition, there is no community-accepted paradigm for verifying, validating, and accrediting these tools to support the C^2 requirements process[16]. Consequently, these tools must be applied cautiously, emphasizing sensitivity analyses within the context of a carefully thought out experimental design, in order to generate useful bounds on requirements.

Prototyping is rapidly becoming a key tool to support the C^2 system requirements process. Formally, prototyping has been defined as "The process of building, refining and evaluating a working model of the proposed operational system or elements of the system during the development process"[17]. The community further distinguishes among exploratory, experimental, and evolutionary prototyping with exploratory prototyping ("Used to clarify, by means of simulators or testbeds, user requirements and desirable features of the target system"[18]) being of primary interest in this paper. Exploratory prototypes are generally accelerated software or hardware development efforts that can best be characterized as iterative, unpolished efforts with a short half-life. Prior experience with these efforts has demonstrated unequivocally that exploratory prototyping should *not* proceed until a clear concept of operations has been articulated and the reason for the prototype is clearly stated (e.g., to determine a preferred human-machine interface). In addition, successful prototyping requires sufficient technical expertise (e.g., software developers, domain experts, user interface expertise), sufficient time, and formal sponsor commitment.

Manned simulator testbeds appear to provide a promising context for developing and validating progressively more detailed requirements in support of evolutionary acquisition. These testbeds go beyond the other tools cited by providing a controlled, repeatable environment for evaluating how teams of operators interact with C^2 systems, under realistic stress conditions, to achieve mission objectives. Thus, they are excellent candidates for the role of the RRDC that is intrinsic to the evolutionary acquisition strategy. For example, the Theater Air Command and Control Simulation Facility (TACCSF)[19], with some modification, could be an effective RRDC to support the validation and prioritization of requirements for the evolving Air Command and Control System (ACCS). However, these testbeds must be used judiciously because of the significant costs associated with developing, accrediting, and employing them (possibly tens of millions of dollars) and the significant times involved in planning, conducting, and evaluating experiments (e.g., many months). Thus, it is important to use simpler, less costly tools to identify key issues, to focus the specific application of testbeds, and to extend the findings derived from testbeds.

Field tests and command post exercises can also play a useful role in identifying shortfalls in C^2 systems and assessing the utility of prototype systems. The utility of these vehicles can be enhanced considerably by applying a structured method for systematically eliciting lessons learned. The Headquarters Effectiveness Assessment Tool (HEAT)[20] is one promising technique for structuring the gathering and processing of exercise data, although it has not yet fully resolved the issue of relating measures of performance to measures of effectiveness.

Finally, considerable insight into pressing C^2 systems shortfalls can frequently be developed by a derivation of lessons learned from operational experiences (e.g., Operation Desert Storm). However, the fragmentary

nature of data collected tends to lead to anecdotal insights.

• *Design.* As a complement to evaluation tools, the information system community is developing and refining a class of automated design tools based on the concepts of structured functional analysis. With the aid of these tools, an analyst can perform some, or all, of the following activities: identify functions to be performed, allocate functions to nodes, estimate information flows, compute loading on communications systems and automated data processing systems, and reallocate functions to optimize loading. Among the design tools being developed and refined are hierarchical, colored Petri Nets[21] and many Computer Aided Systems Engineering (CASE) tools[22]. If these tools are developed appropriately, they have the potential to contribute to the formulation and analysis of relatively fine-grained technical requirements, consistent with the needs of evolutionary acquisition.

• *Programmatic.* In the area of programmatic tools, there is a need to estimate the life cycle costs and schedules associated with alternative system configurations. There are four broad programmatic estimation methods that are used by the community: 1) analog methods, that look at a similar existing system (or at similar components in that system) and adjust costs for market trends and projected inflation/deflation; 2) parametric methods, that are based on statistical relationships developed for key system characteristics (e.g., physical, performance) and depend upon the existence of a broad historical database for similar systems; 3) extrapolation from actual experience, that looks at the actual cost incurred during the fabrication and assembly of prototypes and assumes that production costs of the operational system will be closely related to the cost of the engineering model; and 4) detailed engineering estimates, that develop a "bottom-up" estimate of the system cost at a high level of granularity by summing up work packages to obtain total acquisition costs.

In view of the basic characteristics of evolutionary acquisition, the following tentative conclusions can be drawn. Since the concept of prototyping is so central to evolutionary acquisition, extrapolation from actual experience may prove to be of significant utility. Similarly, analog methods may be useful in evolutionary acquisitions that draw heavily on COTS components. Conversely, the limited experience that the community has had with evolutionary acquisition may limit the utility of parametric methods while the expense and time of detailed engineering estimates will restrict their use. Overall, there is a need for extensive case studies and research to acquire sufficient understanding of the strengths and weaknesses of the competing methodologies.

• *Orchestration.* In looking across the full set of evaluation, design, and programmatic methodologies and tools, it is clear that a broad set will be required to support the development of requirements in evolutionary acquisitions. Although manned simulator testbeds (employing rapid prototyping tools) will play a dominant role, they must be complemented by a credible set of ancillary tools. If this set of tools is to be mutually reinforcing, steps must be taken to accredit, orchestrate, and evolve them. This must include the development and use of common, validated data bases and the selection of self-consistent inputs and MoMs. Because the costs for many of these tools are high and the lead time for their creation and use is long, it is imperative that the community begin to address this problem expeditiously as a precursor to future evolutionary acquisitions. Figure 4 depicts a conceptual set of requirements tools and suggests broad relationships among the component tools. Within this example, expert elicitation is used at the outset to identify perceived operational needs. The other tools are then employed, in concert, to derive specifications that balance mission, technical, and programmatic factors. Subsequently, these tools should be upgraded to reflect the evolution of the system and to support further system development and life cycle needs.

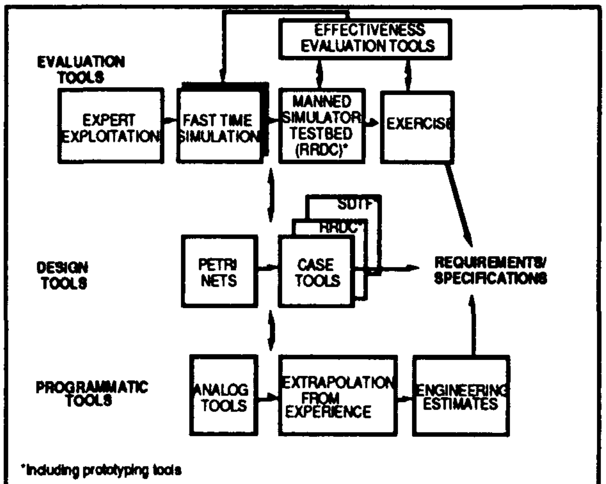


FIGURE 4. Conceptual Set of Requirements Tools

Contractual Mechanisms. Evolutionary acquisition presents unique challenges for contractual mechanisms, primarily due to the creative way in which requirements are developed in the process to accommodate change (i.e., there are no "firm" requirements up front). The problem is exacerbated by the fact that the degree of technical risk varies greatly from activity to activity and the need for flexibility varies greatly from phase to phase or from subsystem to subsystem.

Two basic types of contractual vehicles have been employed in prior evolutionary acquisition programs: FFP and CPFF. Both contractual vehicles pose potential issues for the procuring agency. An FFP contract with vague or incomplete specifications can ultimately result in either "firm price variable product" or a series of costly change of scope orders. Recent experience with the Navy's A-12 program tends to confirm this fear. Conversely, a CPFF contract can make it extremely difficult to contain cost growth.

Preliminary assessments of evolutionary acquisition experience suggest that real competition is the key to contain cost. However, care must be taken to avoid "buy-ins" and to adopt selection criteria that account adequately for technical quality. If these guidelines are followed, preliminary assessments suggest that it is desirable to competitively let an FFP contract with definitive specifications and deliverables. The major challenge is to pursue that approach without compromising the evolutionary acquisition approach. Table II depicts a preliminary multi-phase strategy for implementing that approach. Although this strategy appears promising, it is apparent that the mere choice of contractual vehicles does not guarantee success. Additional experience is required to guide the community in developing contracts that adequately balance technical risk with cost and schedule uncertainties.

TABLE II. A Proposed Multi-Phase Acquisition Strategy

Phase	Characteristics	Products
1. Development of RRDC	• Free/open competition • Full data rights/ documentation • No proprietary software (except COTS) • Man-machine interface vendor independent	• RRDC facility • O&M for an initial period of time
2. Use of RRDC	• Free/open competition	• Specifications
3. Design of core system (with option to implement)	• Free/open competition • Multiple awards (if desired) • SDTF added to RRDC • Implementation phase	• Design specifications • FFP to build • Acceptance test plan • Installed system • Documentation
4. Procuring agency decision	• Alter specifications, if necessary • Exercise option to implement with selected contractor OR • Repackage specification for free/open competition	

SUMMARY

An assessment of the forces that drive C^2 system requirements has served to identify several attributes that a viable requirements process must possess. First, there is the imperative of change. Since C^2 systems must evolve relatively rapidly to respond to a plethora of changes (e.g., geopolitical, forces, technology, constraints), experience has demonstrated the futility in articulating and quantifying detailed C^2 system

requirements fully in advance. Second, it is now appreciated that many, non-homogeneous participants must communicate effectively throughout the requirements process if C^2 systems are to strike an effective balance among mission effectiveness, technical capability, and resources. To facilitate that communication, two critical ingredients are required. MoMs must be developed to characterize the issues of concern for each class of participant and to provide the cross-linkage across participant domains. Similarly, an orchestrated set of accredited tools must be developed and evolved to evaluate MoMs, support design tradeoffs, and provide timely programmatic information. Finally, the process must be responsive to the special characteristics of C^2 systems. These include recognition of the pivotal role that distributed teams of people play in their operations, their high software content, and their need to be interoperable with existing, programmed, and planned systems.

The traditional "waterfall" acquisition approach is largely incommensurate with these attributes. In recognition of these failings, the concept of evolutionary acquisition has emerged over the prior decade. This approach rests on the development and use of an interactive requirements capability, an open, layered architecture, and the concept of incremental implementation and enhancement. Although there is a relatively limited experience base with evolutionary acquisition, much of this experience has tended to demonstrate that the approach has the potential to satisfy the attributes that a viable C^2 requirements process must manifest. However, there are several residual challenges that the acquisition community must face if evolutionary acquisition is to be applied routinely in acquiring future C^2 systems.

First, the U.S. is developing an institutional process that compels the various communities involved to communicate more effectively and to formulate and validate requirements in the domain in which they are expert. This process is still incomplete (notably in clarifying the roles and tools required by the T&E community) and additional steps are required to define fully and refine key institutional relationships.

Second, the nature of the requirements process is such that a complementary set of evaluation, design, and programmatic methodologies and tools is required. The key tool is a manned simulator testbed that provides a capability to define requirements rapidly (i.e., RRDC). However, effective use of this testbed demands the development, coordination, and use of common validated databases and the selection of self-consistent inputs and MoMs.

Finally, it is being recognized that the evolutionary development of requirements will strongly influence the contractual vehicle that is selected for a C^2 system. Preliminary experiences suggest that several alternative contractual vehicles can work, if applied wisely, although no particular vehicle guarantees success. In order to contain costs, efforts must be made to inject free and open competition throughout the acquisition process. This suggests the desirability of a multi-phase acquisition strategy with well-defined and documented deliverables at the culmination of each phase.

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ADP HARDWARE

and

SOFTWARE

A PROPOSED MEANS OF UPGRADING GOVERNMENT COMPUTING SYSTEMS

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ABSTRACT

The Department of Defense (DOD) has a history of retaining obsolete information technology—computing systems—to the point of degrading the productivity of the technology users. This paper describes an approach and suggests a facility-wide program to prove that the commercially accepted method of trading in "unusable" equipment for credit toward the purchase of new equipment is perfectly feasible for the Federal Government.

A primary factor contributing to this misbelief is the perceived inability to "trade-in" or exchange old, out-of-date computer systems to defray costs through the federal procurement system. This paper will attempt to show not only that "trading in" is a legal, workable, and cost-effective solution, but also will provide an example of a contract requirements document that is being used in an effort to effect an upgrade of the current personal computing technoiogy at the Naval Weapons Center.

The federal procurement system is not the only factor inhibiting cost-effective upgrading of personal computing systems in the workplace. Another factor is the generally perceived requirement to advertise (within the Federal Government) all equipment intended to be traded in or excessed.

Regulations governing the "exchange" of government property are not those generally used by procurement or plant property personnel, and because those regulations do have a tendency to be conflicting, vague, and not specific in direction, as a result, the permissibility of trading in obsolete computing equipment is not widely known. The documentation and administration associated with removing equipment from the plant account inventory for exchange is time consuming; those who do know of the process generally avoid it. The current method of upgrading obsolete personal computing systems is to acquire new and excess the old. The excessed equipment then sits in government warehouses for perhaps years before being transferred to other facilities or often, as a last result, sold at government auction. The Government then realizes only a poor return on the excessed equipment because of depreciation. It is becoming painfully clear in this age of declining defense dollars that the DOD (and the Federal Government in general) is not taking advantage of the most cost-effective methods available.

A review of future potential information/computing requirements at the Naval Weapons Center has indicated a need to upgrade/replace aging computer systems in a volume and within a time-frame sufficient to warrant the consolidation of these requirements into a single contracting action that would result in reduced administrative and capital-equipment costs and would produce offsetting revenues because of trade ins.

This paper describes a concept for upgrading personal computing systems at a single facility utilizing a single (procurement) that would encompass a trade-in-for-credit approach. This approach would allow

individual users the ability to upgrade personal computing systems as these systems become obsolete, using a cost- and time-effective method in the most time efficient manner. The federal method would then be consistent with both prevailing commercial practice and all applicable procurement regulations.

INTRODUCTION

The idea of trading in an obsolete item for a credit toward a replacement item is neither new nor unique. This practice has been in existence in the commercial world for many years. In the commercial world of ADP, trading in for credit has been practiced more in the mainframe and minicomputer world than in the personal computer field.

The general feeling of government procurement specialists is that trading in is not allowed. It is easy to understand this misbelief because the applicable federal laws and regulations are unclear in this area. The following paragraphs describe the difficulty in determining a clear regulatory guideline to initiate a procurement for personal computers with an allowance for trading in out-of-date technology for credit toward the purchase of newer or expanded-technology equipment.

The Federal Acquisition Regulations (FAR) are those regulations generally used by procurement personnel as rules and guidelines for pre-, post-, and administration procurement actions.[1] Review of the FAR is the logical first step in the process. The FAR refers acquisition personnel to the Federal Information Resources Management Regulation (FIRMR) "for those special policies and procedures applicable to acquisition of certain automatic data processing, telecommunications, and related resources." The FAR does not address the acquisition of ADPE but rather defers to General Services Administration (GSA)—the agency in the Federal Government that has been delegated this responsibility.[2]

The section of the FIRMR that addresses Policy is Chapter 201, which contains 45 subchapters.[3] Reading the Table of Parts to Section 201 of the FIRMR quickly guides the reader to two applicable subchapters, C and D. Subchapter C establishes the position for the Federal Government regarding obsolete ADP and states, in part: "The acquisition of (1) outdated ADPE and (2) ADPE that is no longer being installed by the commercial (non-government) market to satisfy requirements for commercially available, general purpose ADPE, most often does not achieve lowest overall cost, price and other factors considered over the system life."[4]

The subchapter that specifically addresses exchange/sale of ADPE states "Upon determination by a federal agency that government-owned or -leased ADPE is excess to its needs or government-owned ADPE will be replaced pursuant to the exchange/sale authority of FPMR Part 101-46, this information shall be reported as set forth in 201-33.011."[5] It also goes on to state "201-33.011 (d). . . A written administrative determination has been or will be made to apply the exchange allowance or proceeds of sale to the acquisition of similar items by other than lease" shall be displayed prominently on the original and four copies of the SF 120 when reporting ADPE that is to be replaced pursuant to exchange/sale provisions of FPMR Part 101-46. . . Without exception, both cash (sale) or exchange (trade-in) offers shall be solicited. . . ." The Federal Property Management Regulations discuss the disposal of ADPE in the following manner: "If not transferred for other reutilization among federal agencies ADPE may be disposed of as provided in this Subpart 101-46.4."[6]

The Federal Property and Administrative Services Act of 1949 also addresses surplus property. Subpart 101-46.402 Solicitation of Bids states "The objective shall be to obtain

the maximum return to the Government from property sold or exchanged. Both cash and exchange (trade-in) bids shall be solicited in each instance . . . ."[7]

All of these references require that prior to the actual trade in, (equipment) shall be reported on an original and four copies of SF 120, Report of Excess Personal Property. "The SF 120 shall be submitted to the. . .address by the holding agency at least 60 calendar days before the anticipated release date as determined by the holding agency." This lead time and paperwork, of course, just add another layer of delay to the acquisition process, which further discourages the Government from seeking the financial advantages of trading in out-of-date equipment.

The handbook *Basic Laws and Authorities of the GSA* was reviewed for laws governing disposal (or trade in) of surplus or obsolete government property. One of the major forces behind GSA is the Federal Property and Administrative Services Act of 1949 (40 USC 484). Section 203 states: "(a) Except as otherwise provided in this section, the (GSA) Administrator shall have supervision and direction over the disposition of surplus property. Such property shall be disposed of to such extent, at such time, in such areas, by such agencies, at such terms and conditions and in such manner, as may be prescribed in or pursuant to this Act. (b) The care and handling of surplus property, pending its disposition, and the disposal of surplus property, may be performed by the General Services Administration or, when so determined by the Administrator, by the executive agency in possession thereof or by any other executive agency consenting thereto. (c) Any executive agency designated or authorized by the Administrator to dispose of surplus property may do so by sale, exchange, lease, permit, or transfer, for cash, **credit**, or other property under the provisions of this title. (3) Disposals and contracts for disposal may be negotiated, under regulations prescribed by the Administrator, without regard to paragraphs (1) and (2) of this subsection but subject to obtaining such competition as is feasible under the circumstances, if. . .(e) the estimated fair market value of the property involved does not exceed $1,000."[8] Since the fair market value of most "obsolete" or old-technology personal computers generally does not exceed $500, I interpret the above to exempt the trading in of personal computers for credit from the advertising of excess resources requirement described further on.

The Department of Defense also addresses this issue. The DOD 7950.1-M states: "When it is determined that Government-owned AE [automated equipment] should be replaced, Exchange/"Sale" shall be considered. Exchange/"Sale" is a means of transferring the equipment to be replaced to another Government Agency, with reimbursement, or to the supplier of replacement AE for a trade-in allowance on the contract price so that proceeds can be applied in whole or in part payment for the replacement AE."[9]

The DOD FAR Supplement (i.e., DFAR) authorizes "Exchange (trade-in) property."[10] First, DFAR defines "Exchange (trade-in) property" as "property not in excess of the needs of the owning DOD component, but eligible for replacement because of obsolescence, unserviceability, or other valid reason, that is exchanged and applied as whole or partial payment allowance toward the acquisition of similar items." Second, under this policy, "It is DOD policy to use exchange processing for replacing eligible nonexcess items. It shall be used to the maximum extent possible when such transactions foster the economical and efficient accomplishment of an approved program." The DFAR then goes on to describe the procedure to use when "trading in" such items.

ADPE is neither on the Property Eligible for

Exchange list nor the Property Ineligible for Exchange list of the DFAR. In this instance, the DFAR advises "Categories of property not listed below or not included in 217.7003-2 are also eligible for exchange if designed and constructed for the same specific purpose."[11] It is therefore assumed that DOD supports this type of contracting mechanism for replacing out-of-date or unusable ADPE.

One way to facilitate contracting for trade-in would be to consolidate individual requirements into what is sometimes referred to as a "Corporate" or "Consolidated" contracting effort. In such instances, as in this specific application, each individual requirement for an upgrade of a system would fall well below all of the policy and contractual regulations governing required approvals. As a result of consolidation efforts though, a false picture is presented that indicates that the requiring organization should proceed with the necessary steps for approval from the various approving officials and agencies. If the contract vehicle being used allows for delivery orders, each individual action should be strong enough to stand on its own because the equipment being upgraded is owned by a large number of individual projects, programs, and sponsors. In addition, a contract of the type proposed is intended to support all manufacturers of the equipment and no specific manufacturer is being singularly sought.

CONCLUSION

The August 31, 1990, issue of The Kiplinger Washington Letter stated, "Used-computer business will grow and become better organized, as equipment bought in sales boom of mid-'80s comes due for replacement. Some computer stores will take trade-ins or help you sell your old stuff. A good deal for thrifty buyers. . .and growth for brokers and dealers."

The value of technically obsolete or out-of-date ADPE is on the rise. The demand for this equipment by educational institutions and the home market is increasing.

The demand for leading-edge ADPE is continuous in the many facilities of the Federal Government, especially in the Department of Defense. The demand by taxpayers for more cost awareness by the Federal Government is increasing. The demand for a more professional approach to contracting is being stressed by the Congress.

The cost benefits associated with trading in old equipment for credit toward new equipment are obvious. In the Apple environment, a trade-in credit of between $100 to $900 per system could be realized.[12] In the Disk Operating System (DOS) environment, since the initial cost per system is generally lower, a credit of between $100 and $200 could be realized.[13]

In addition to the trade-in factor, consolidated contracting—or having a single contract action for selected projects in a given activity—is a major cost-saving practice. The federal regulations recognize but do not obviously promote the trading in of PC-level ADPE for credit. The Federal Property and Administrative Services Act of 1949 (as amended) does not address trading in nonexcess equipment, but it does set a limit on overview by the GSA Administrator of the disposition of equipment based on estimated fair-market value not in excess of $1,000.

Because the fair-market or trade-in value of personal computers does not exceed the $1,000 minimum set by the above-mentioned act, the actions affecting this equipment are the responsibility of the owning activity. This trade-in option should be inserted into contractual documents, be promoted, and the $1,000 limitation should be raised to encourage cost saving in the

ADPE arena.

In conclusion, trading in lower-dollar-value ADPE for credit is acceptable and supported by the federal regulations and laws. The laws and regulations governing acquisition practices in the Federal Government are so convoluted that the average contract specialist doesn't have the luxury of time to untangle the regulations and substantiate the legality of the action. Exhibit 1 is a diagram of the current full procurement process. It is obvious that the process in itself is very complex. Exhibit 2 is a diagram of the current turn in or excessing process. This is in addition to the overall process.

A requirements document is being drafted by the Information System Resources Management Branch of the Naval Weapons Center. It is intended that the initial procurement document encompass all manufacturers' types of personal computers and have a provision for either single or multiple awards to competitors. It is further intended that the initial effort be a prototype and be well within the dollar thresholds for competitive acquisition as set by the General Services Administration/Federal Information Resource Management Regulations. The initial, prototype effort is intended to establish both a need (customer) and allowability (administratively, contractually, commercially) for a contract of this type.

Discussions have been opened with the Automatic Data Processing Selection Office, Washington Navy Yard, to develop an awareness of this project.[14]

As part of the initial research into commercial support for this effort, a Presolicitation Notice was sent to determine comparability with standard commercial practices and to establish a list of prospective offerers.[15] It is anticipated that this Notice will be synopsized during the first half of fiscal year 1991.

ENDNOTES

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2/ Federal Property and Administrative Services Act of 1949, As Amended, Public Law 152, Ch. 288, 63 Stat. 377 (Codified as amended in scattered sections of U.S.C. and 41 U.S.C. (Brooks Act).

3/ 39.001 Policy.

4/ 201-24.206 Acquisition of Outdated ADPE (a).

5/ 201-33.003-3 PART 201-33-Reuse of ADP Equipment, Federal Information Resources Management Regulation (Amendment 7, March, 1986) Page 33-3.

6/ Subpart 101-46.4 Disposal and 101-46.4300.1 Automatic Data Processing Equipment.

7/ Disposal of Surplus Property (40 U.S.C. 484) Sec. 203 (a)

8/ General Services Administration. Basic Laws and Authorities of the General Services Administration. Washington, D.C., GSA, 1987. The term surplus property means any excess property not required for the needs and the discharge of the responsibilities of all Federal agencies, as determined by the Administrator.

9/ DOD 7950.1-M Defense Automation Resources Management Manual of September 1988, 4060, 2-8, D-5 E. Exchange/"Sale" AE.

10/ Part 217 Special Contracting Methods; Subpart 217.70 Exchange of Personal Property, 217.7001 Definitions, and

217.7002 Policy.

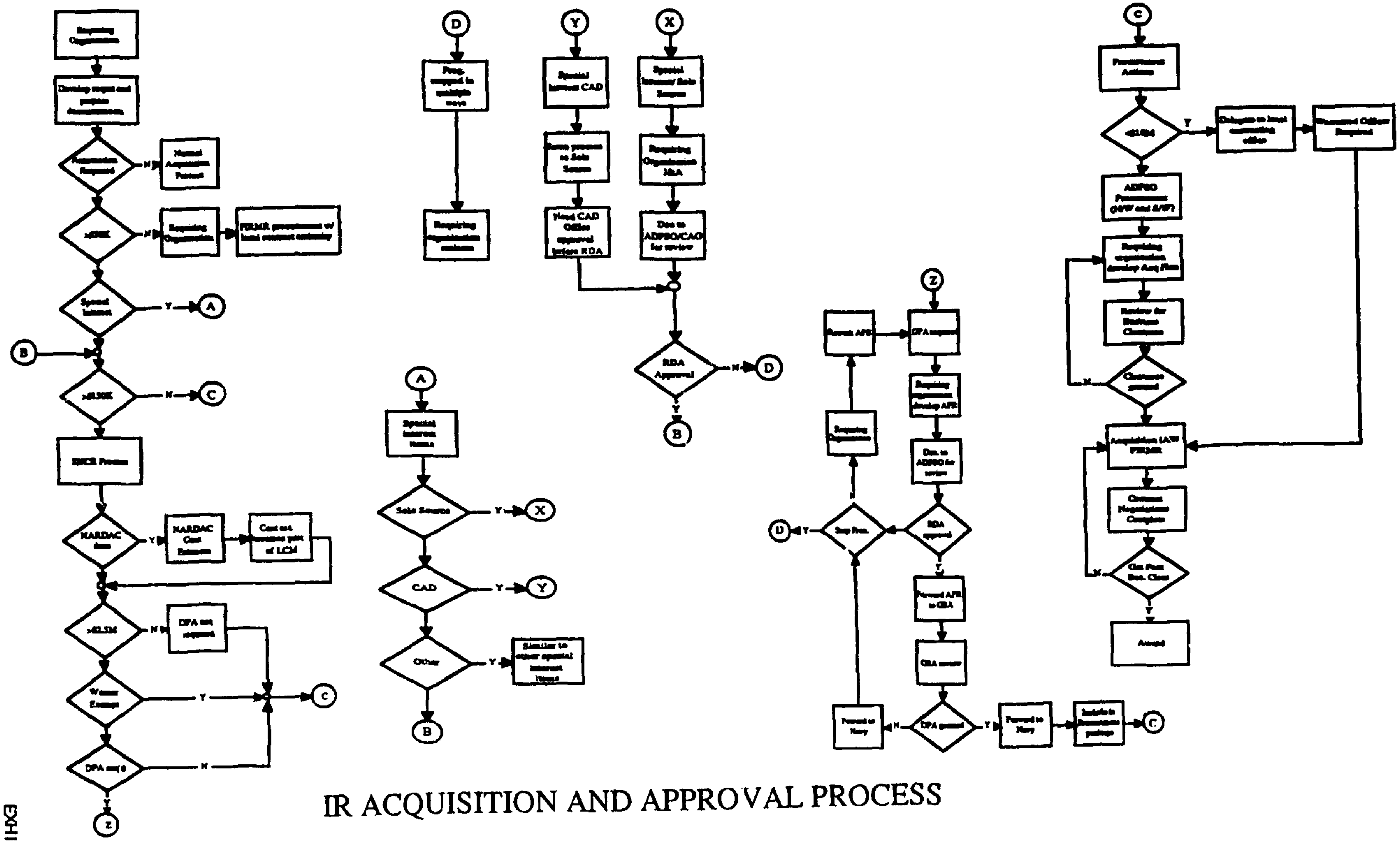
11/ GSA Handbook.

12/ Telephone conversation with Personal Support Computers Representative, Tom Darke, 10431 Santa Monica Blvd. West Los Angeles, Calif., on 5 November 1990.

13/ Telephone conversation with Falcon representative, Steve Hertzfield, West Coast Representative, on 7 November 1990 (for both Apple and DOS costs).

14/ Telephone conversation between Dian Katzenstein, NWC, and Regis Novasell, ADPSO, 8 and 9 November 1990.

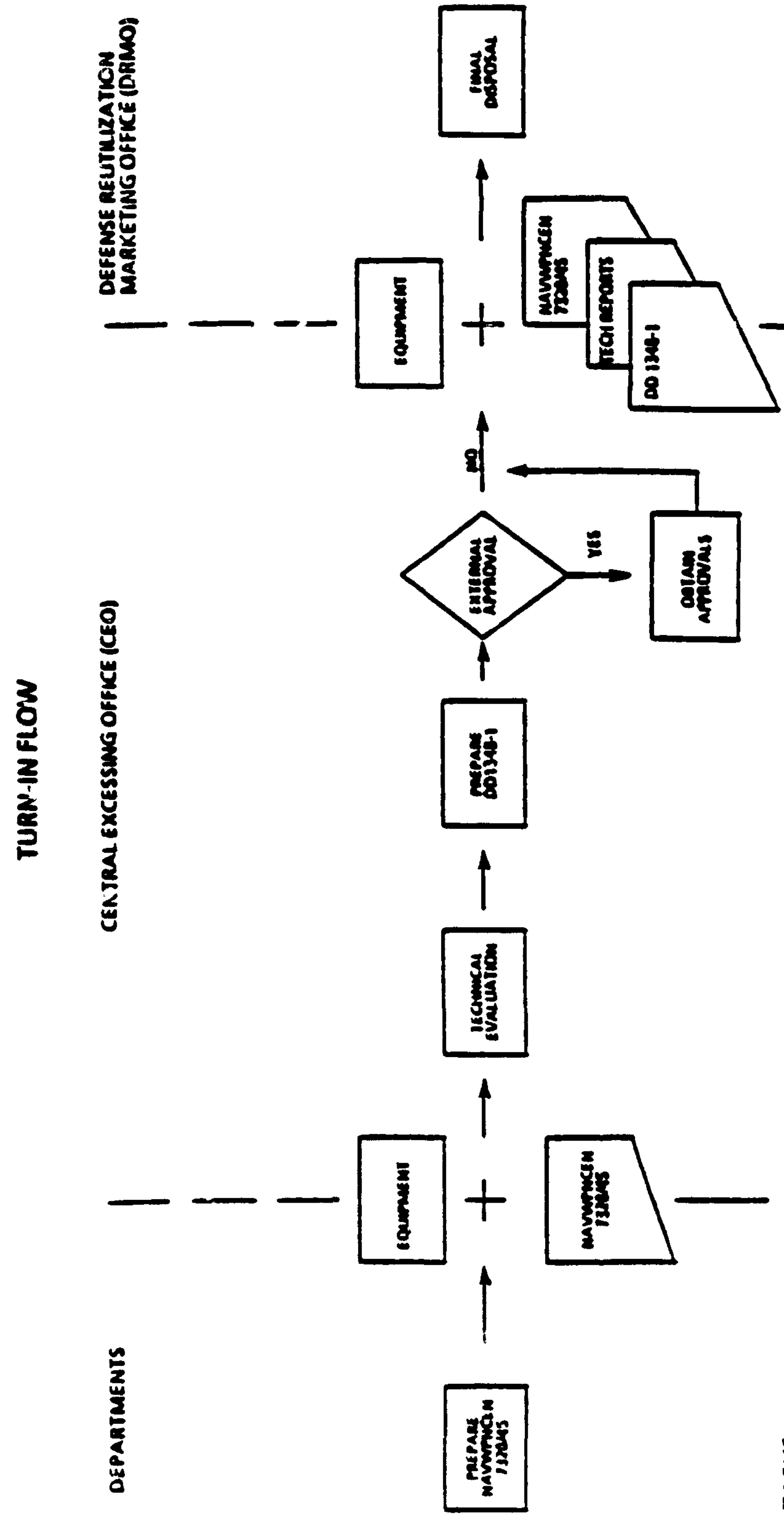
15/ FAR 15.404 (b) Presolicitation Notices and Conferences.



IR ACQUISITION AND APPROVAL PROCESS

EXHIBIT 1

TURN-IN FLOW



TASKS

Departments:

- Obtain dept. authorization
- Prepare NAVWPNCEN 7320/45
- Schedule delivery
- Deliver to CEO

Central Excessing Office (CEO):

- Schedule delivery from departments
- Evaluate equipment at time of acceptance
- Schedule review "teching"
- Prepare DD 1348-1
- Obtain all special authorizations
- Watch for precious metals
- Maintain work in process file and take follow-up action
- Make entries to CERMS

Defense Reutilization Marketing Office (DRMO):

- Dispose of equipment according to DRMO procedures
- Upon final disposition provide #4 copy of DD 1348-1 to CEO

EXHIBIT 2

IMAGINING, INNOVATING -AND- IMPLEMENTING THE PROCUREMENT KNOWLEDGE NETWORK (PKN)

Dr. Diane R. Murphy, Procurement Automation Institute

ABSTRACT

Automation plays a role in the majority of government procurement offices; the PC is nearly as common as the Federal Acquisition Regulation (FAR) itself! These PCs are, however, primarily used to access information stored locally (i.e. on the PC itself or directly accessible through a local area network). Before the PC can be used effectively in this environment, the information it contains must be entered, updated, and otherwise managed. This can be a very complex and time-consuming process and is performed thousands of times in the government procurement environment.

Imagine this PC as the hub of a network of information resources, maintained by the source of such information. Imagine being freed from the chore of updating your information resources or waiting for information to be distributed to you from a third-party.

Think about the productivity gains to be achieved by each of the many thousands of government procurement offices throughout the country by gaining immediate access to information resources which are kept up-to-date by the source, not by you or someone in your organization. Resources such as the Debarred and Suspended List, GSA Schedules, small and disadvantaged business sources, product and service codes, *Commerce Business Daily* information, and the Federal Acquisition Regulation and its supplements.

This paper looks into the future with the introduction of a Procurement Knowledge Network (PKN), a government-wide system dedicated to making current and complete procurement related information, available directly to everyone who is performing a procurement function for or with the government.

The reasons for the network are first established in the framework of *"Total Quality Management (TQM)."* The individual government sources of information (General Services Administration, Small Business Administration, Department of Labor, etc.) practice *"Next Operation as Customer (NOAC)"* in providing support to the many thousands of procurement officials trying to make the best buy for the government. The results are increased productivity, improvements in the quality of the acquisition process, better business decisions, etc.

The paper next reviews the technology, which exists today, to implement PKN. This includes the electronic message transfer capabilities available through existing mechanisms such as FTS 2000, as well as implementing strategies such as

electronic mail, bulletin boards, electronic data interchange, and information retrieval systems.

The concept behind the network is that the organizational sources of information (such as GSA for the FAR or the Department of Labor for Wage Determinations) reorient their responsibility in the 1990s to disseminate information electronically and to make such information readily accessible to their constituent users. Such organizations can often achieve considerable productivity gains within their own processes by soliciting "self-help" approaches.

For such a network to be fully operational by the end of the 1990s, the implementation process must begin, **today**, with recognition by the procurement community that the "electronic networking of procurement knowledge" from its many sources is an **innovation** from which we would all derive benefits.

INTRODUCTION

Procurement automation is here to stay. Most offices are using, as a minimum, personal computers for activities such as wordprocessing, procurement tracking, and regulatory research. Most of the use of this automation is to provide "local" access to information which is stored directly on the computer or on a "file-server" accessible through a local area network. There is, however, often little or no electronic communication between an individual procurement office and other parts of the organization or with the vendor population. When it is used, electronic communication usually involves the sending of specific information directly to another point (e.g. transfer of electronic mail messages, sending of a synopsis electronically to the *Commerce Business Daily* office in Chicago, or electronic data interchange [EDI] with a trading partner).

The procurement process, however, is complex requiring access to procurement-specific knowledge which is diverse and constantly changing. This information includes the regulatory framework for procurement as established in the Federal Acquisition Regulation (FAR) and its applicable supplements; availability of small or disadvantaged businesses who can provide a particular goods or service; information on debarred or suspended vendors; availability of a particular commodity through a GSA FSS Schedule, or a Wage Determination from the Department of Labor, etc.

Many of the processes which generate this procurement information are themselves automated. For example, Apple, MacIntosh desk-top publishing tools are used in the FAR publication process. This information is then transferred to paper before it is disseminated to the constituent-user population. Where such information is available electronically, it is usually *"reautomated"* by private companies and *"resold"* back to the end-user. This is particularly true for the regulations themselves, where some ten companies regularly scan or rekey the hard-copy regulations and provide search services back to the government.

Another major area of concern in getting the information to the end-user is the distribution process itself. This process is generalized and illustrated in Figure I.

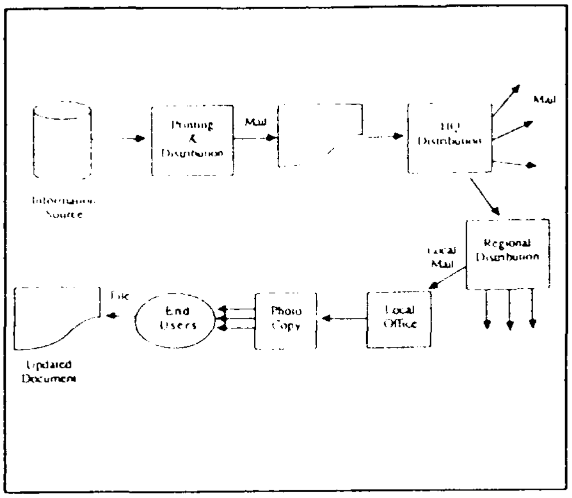


Figure 1
Generalized Distribution Process

As illustrated, the process of transferring the information from the source to its ultimate location is often complex and time-consuming. Errors may be made at any of the steps in the distribution process resulting in a loss of some or all of the information. In addition, because there is no scheduled date for the information to appear, there is often no easy mechanism to identify that it is <u>not</u> missing except when it is clearly needed, and not available.

When the information finally reaches the end-user (either in hardcopy or electronic form) it often needs to be copied and the information updated (e.g., by filing change pages in a manual or performing some update process on the disk). Because the nature of this information is constantly changing, this updating process can be a significant burden in a small procurement operation.

RESPONSIBILITIES OF INFORMATION SOURCES

The Federal government has a myriad of departments and offices which are responsible for the generation and maintenance of information sources important to the procurement process.

Production of several of these sources, lie within the General Services Administration, although through no centralized organization. For example, at the regulatory level, the FAR Secretariat is responsible for the maintenance and update of the FAR; the Office of Information Resource Management Policy is responsible for the Federal Information Resources Management Regulation (FIRMR); and the Office of Acquisition Policy is responsible for the General Services Administration Acquisition Regulation (GSAR). Other GSA offices take responsibility for the Debarred and Suspended List, etc.

Other governmental entities having individual requirements to provide other information central to the procurement process include the Department of Labor (Wage Determination), Department of Commerce (*Commerce Business Daily*); the Small Business Administration (certification and management of small and disadvantaged business; and the Department of Defense (multiple information sources from regulatory supplements through vendor information [CAGE Codes]) etc.

Each of these organizations is responsible for the creation, maintenance, and dissemination of information. Most do a diligent job at the creation and maintenance process, with the main problem being timeliness. Most, however, fall short in the dissemination process. Information dissemination is largely executed as a printed product (e.g. the Federal Acquisition Circulars) through the standard

governmental publication processes. This includes public notification through the *Federal Register* and dissemination, on a subscription basis, through the Government Printing Office.

Is this sufficient? Should the end-user (such as the government procurement official) have to rely on his own resources to track down and obtain copies of the information requires to do the job of buying? To date, we have accepted this responsibility and have developed mechanisms to ensure that our knowledge-base is current and up-to-date.

But with the cut-backs in personnel and resources throughout the government, shouldn't we all be asking is there a better way? Shouldn't we be asking for improvements in the service levels from the many information sources on which we rely?

Government-wide Total Quality Management

The Federal Government has enthusiastically embraced the concepts of total quality management (TQM) and the continuous improvement process CIP (Reference 1). Managers are aware of the economic changes that make it important for American business (including the government) to adopt this new business philosophy (Reference 2).

The TQM is essentially a process to achieve world-class management through deliberate disciplined, structured employment of the best-known management techniques. CIP is the process of transition from a traditional management culture to a TQM management structure and relies on the elements shown in Figure 2.

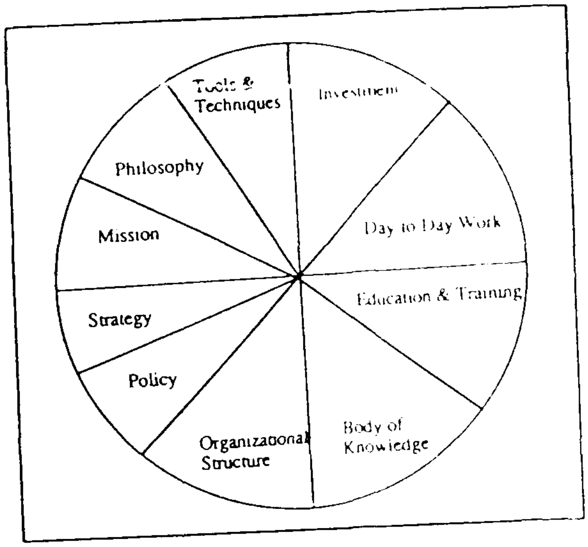


Figure 2
Elements of the Continuous Improvement Process

Central to TQM and CIP is the role of technology since it provides:

- A focal point for change
- A force for democracy
- A dissemination of knowledge
- Source of productivity growth
- Contributions to quality improvement
- Factor in competitive advantage

TQM, and the use of technology, has been successfully applied in all parts of the manufacturing industry. According to a study on productivity conducted by the Illinois Institute of Technology, blue collar productivity in manufacturing has been consistently above 80% and rising, while white collar productivity in office environments has been below 40% and falling. Service quality is at least 20 years behind product quality even in organizations with TQM initiatives. In manufacturing, cycle time-the clock time that elapses between

the start and completion of any operation-is second only to quality in importance. But cycle time in support services (including information dissemination) is virtually unknown (Reference 3).

The concept of *"next operation as customer (NOAC)"* is vital to the process of TQM/CIP in a service environment such as information dissemination.

The basic principle of NOAC is that if the external customer is king, the internal customer is at least a prince. The internal customer needs to be cultivated and his needs, requirements, and future expectations determined.

In the procurement community, each procurement official in any agency procuring office, however small, should be considered a valuable and important customer to the information suppliers such as GSA, DoD, and DOL. The measurement of quality for the information source must be the ability to disseminate accurate and timely information directly to the end-user not merely, to make it publically available.

The dissemination of procurement information must be considered as a single process, across departments and across agencies. Each subprocess receives inputs from an internal supplier-the previous operation. Each subprocess has a process user, who adds value to that input and converts it into an output for the next internal customer-the next operation.

The internal customer's requirements must be carefully determined, just as an external customer's must. The new discipline of quality function deployment (i.e. the development of firm product specifications) can be applied, in a simpler form, into the internal supplier's performance parameter. The internal customer's requirements must be measured in terms of the performance parameters. The methods of measurement, the frequency of measurement, and the feedback mechanism from supplier to user must be mutually predetermined. This process is shown diagrammatically in Figure 3.

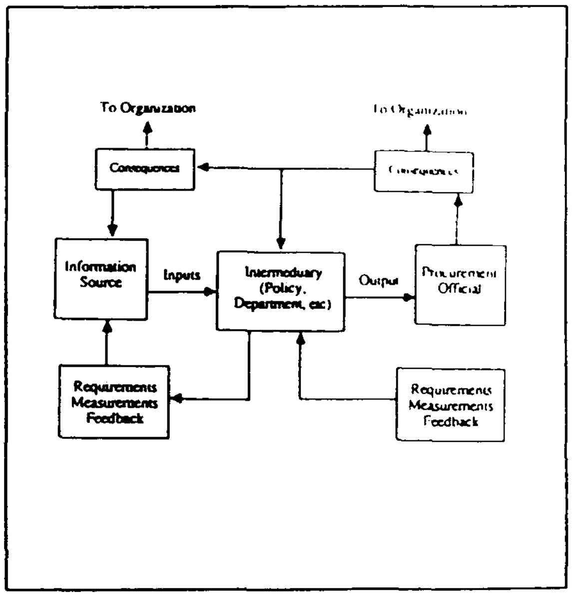


Figure 3
A Schematic Representation of Next Operations as Customer in Procurement Information Dissemination

This diagram shows how requirements and measurements are fed back to the supplier and the intermediary, with the consequences fed back to the supplier, the intermediary, and the organization.

THE PROCUREMENT KNOWLEDGE NETWORK (PKN) - A Potential Solution

If the procurement community accepts TQM and NOAC, it becomes essential to solve the problem of the procurement information dissemination such that:

• All procurement officials are treated equally and have equal access to the information essential for their quality performance.

• The information suppliers each accept that their responsibility does not stop when the information is generated, but encompasses getting it to the user, in a timely and useable manner.

• The role of technology is maximized not only in the generation of the information, but also in its dissemination.

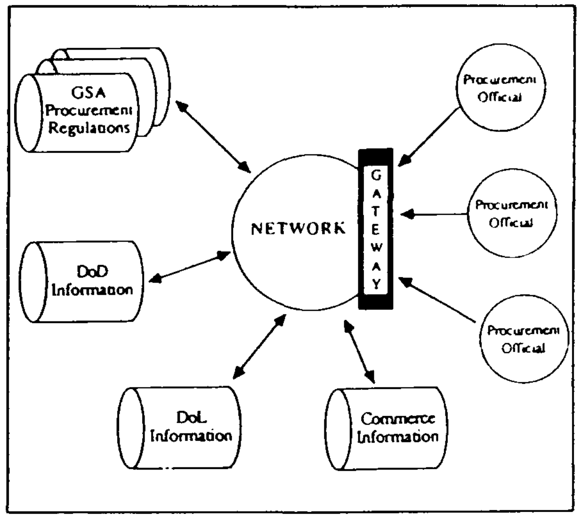


Figure 4
Overview of Procurement Information Network

Organizational limitations in the government must also be considered when looking at potential solutions. Government-wide organizations such as the Office of Federal Procurement Policy, concern themselves with policy not implementation. This is illustrated by the recent interview with the Administrator, OFPP (Reference 4). Concern was expressed over the need to upgrade the professional status of the acquisition workforce, and for the need for the procurement official to improve themselves and their qualifications. However, there was not one mention of any technological initiatives which are being considered to assist the improvement of the acquisition process or of other TQM initiatives within the procurement process.

The potential solution lies in improvements at the source of the information, and the ability to "network" these individual information sources, so making it available to any procurement official who needs it. This concept of a "procurement knowledge network" is illustrated in Figure 4.

Individual information sources become responsible for making their knowledge-base available in electronic form and providing a host-computer environment from which it may be accessed via the "network." Most of the information required is prepared in an electronic form in the current production environment, and as such making the information available electronically should not place a large burden on the individual responsible agency. There is an abundence of off-the-shelf software to implement access including full-text search systems, relational database management systems, bulletin board software, etc.

Similarly the basic "infrastructure" for the network basically exists. The current FTS 2000 environment, used for voice communications, is equally capable of handling the data transfer associated with the remote access to the "information sources".

Since it is likely that each of the information sources will utilize different hardware/software platforms to implement the "information access," it is important to offer the procurement official some "gateway" which will standardize, to some extent at least, the access and search requirements for each information source. This technology is not new and is widely used in the library community where information specialists access directly into a myriad of information sources.

The gateway technology can exist either on the PC of the procurement official or be part of the enabling "network" environment.

ADVANTAGES OF PKN TO THE PROCUREMENT OFFICIAL

The advantages to the procurement official are substantial. First, he is freed from the burden and responsibility that his local information sources are current and complete. He accesses directly into the information suppliers' database without regard to his geographic location or organizational position. Once the latest information is obtained, he can "down-load" only those pieces of information that are pertinent to his individual situations. They are immediately available to him in an electronic form, and may be manipulated directly by him to meet his particular need.

He can be freed from many of the paper-intensive processes which make today's procurement process labor-intensive and bureaucratic. One such example might be direct and immediate access to Wage Determinations from the Department of Labor. This process currently takes 30 to 45 days and most often results in the need for solicitation amendments.

EXTENDING THE NETWORK TO INCLUDE VENDORS

Vendors could be provided access to information on the network in much the same way as Federal contracting personnel. Access to such information would improve the subcontracting process and would ultimately benefit the government. This is similar to the use of the *Commerce Business Daily* to advertise subcontracting opportunities.

In addition, there are ways in which the network could be extended to cover the solicitation and ordering processes.

One such example is the increased use of **electronic bulletin boards** to replace the manual solicitation boards.

Experiences, such as at the Naval Supply Center in Jacksonville, Florida show the advantages to the government in opening up competition for a large number of otherwise restricted procurements. Another example is the Hanford Proposal Board, initiated by the Department of Energy (DOE) in cooperation with its major management and operating contracts (Reference 5).

A second area is the transfer of ordering and invoicing information through the use of **electronic data interchange (EDI)**. The Deputy Secretary of Defense has called for the maximum use of EDI. To support its EDI goals, DOD has named the Defense Logistics Agency (DLA), as its Executive Agent for its Electronic Commerce (EC) through EDI program. One of the initial steps of this program is the

development of the Operational Pilot Network (OPN) which will include many of the Defense agencies now working toward EC functionality (Reference 6).

The proposed "procurement knowledge network" goes farther than this in its concept of information dissemination within the organization as well as outside of it.

Another initiative is to extend the use of the network to allow the vendor community to perform functions which are, at present, performed by government agencies. This extends the TQM/CIP model. The Federal government has a larger purpose than to make itself more efficient and effective. The real purpose of a government is to fulfill the needs of the citizens. The idea that citizens intercede directly with their government through technology is more common in Europe (Reference 7). It is becoming a fact in this country; for example, the on-line filing of tax information to the Internal Revenue Service (IRS).

There are many instances when this approach can be used in the procurement community. One simple example is application of a new vendor for a CAGE code. This is a timeconsuming, complex and frustrating process which ultimately holds up payments to the vendor. A simple on-line transaction, with necessary validation and verification checks, could be made available for direct access by the vendor.

IMPLEMENTING PKN

The implementation of the PKN is not technologically complex; it is largely a management issue.

First, using the TQM/CIP model, the process of "improved electronic information dissemination" must be recognized as a critical-path item in the achievement of TQM in the procurement process. Once recognized, the requirements process must be initiated such that the needs of the end-user (the procurement official in every procurement office) can be heard and analyzed. This requirements definition process is an important first step in establishing the scope of the network and in establishing priorities for its implementation.

Once the exact information access requirements are established, a government-wide program must be initiated to work with the "information sources" to establish and coordinate their automation initiatives, where practical. Such early coordination will assist in the ultimate goal of the Procurement Knowledge Network (PKN). Some of this is occurring now; for example, GSA's initiatives to coordinate publication of both the FAR and FIRMR on CD-ROM using the same technology. This initiative coordinates offices within GSA, and similar activities should coordinate customized projects among civilian agencies and with DOD initiatives such as the Operational Pilot Network (OPN).

CONCLUSIONS

The acquisition community has embraced TQM as a methodology to maximize the service provided to the organization. Several initiatives are under way to increase the competency and professionalism for those involved in the acquisition process, including more discretionary power. The Procurement Knowledge Network (PKN) is an integral part of this change process since it

simplifies the access to "information" essential to decision-making in the procurement field.

There is no doubt that "mature" technology exists to make PKN a reality. What is needed, however, is a commitment by management to make it "happen."

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AUTOMATED PROCUREMENT

ICIS - The Future in Contract File Storage, Retrieval, and Research

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ABSTRACT

ICIS is the Integrated Contract Imaging System. ICIS is the collective name for projects developed to take advantage of the unique attributes of imaging technology as applied to the contracting environment. The concept for the initial prototype/production applications were designed in the contracts directorate of the F-16 Systems Program Office (SPO) at Aeronautical Systems Division. ICIS uses off-the-shelf imaging technology to reduce storage space, duplication costs, research time, and the occurrence of lost/misplaced documents. The results are increased productivity and real dollar savings. ICIS software provides the ability to build an on-line conformed contract which includes contract file sections and supporting documents. These files and documents are available simultaneously to all on-line users in real time at the users desk via a Personal Computer (PC). Imaging allows multiple users to view the same document, even the same page, simultaneously (this is known as the "multi-user" concept). The multiple viewing is limited only by the number of work stations on the system, regardless of location. The ability to provide multiple access to the same document throughout the organization without creating additional paper copies, improves work flow, saves paper, and creates a less cluttered work environment. By reducing paper handling and paper copies, the F-16 SPO is able to pursue the goal of paperless office management and a paperless contracting environment.

INTRODUCTION

Background. With today's shrinking defense budgets and increasing national debt, all Department of Defense (DOD) agencies are looking for ways to not only "do more with less", but to do it smarter and more efficiently without working harder and longer hours. One of the ways to work smarter is to look for and identify inefficiencies in the current method of operations. Even as programs get smaller as a result of budget cuts, it takes as much effort and as many steps in the acquisition of 400 aircraft as it does 600 aircraft.

One of the biggest handicaps to the reduction of inefficiencies at the worker level was the feeling of being unable to affect changes that individuals believed would make a difference. This handicap was overcome by the implementation of Total Quality Management (TQM) at Aeronautical Systems Division (ASD) and particularly in the F-16 Systems Program Office (SPO). The spirit of TQM dictates that individuals should forward their ideas to management who would then listen and act upon the ideas. The development of ICIS is an example of the workers putting forth an idea to make a difference in their directorate and SPO. The purpose of this paper will be to present the paperless contracting solution, known as ICIS, employed at the F-16 SPO. Discussed will be the problems in the manual process, development of the application, and the solutions and cost savings generated by implementing ICIS in a contracting

organization. In conclusion, there will be a brief discussion of future ICIS projects.

What is Imaging? Imaging is the storage of documents in a computer's memory for later retrieval and use. It is similar to making a photocopy. The computer stores an exact replica of the original that can be displayed on a computer screen (monitor) or printed on a laser printer when a hard copy is required. The document in the image form is unalterable when stored on the system. Documents can be text, handwritten notes, forms, pictures, graphs, or all possible combinations.

What is ICIS? ICIS is the Integrated Contract Imaging System. ICIS is the collective name for projects developed to take advantage of the unique attributes of imaging technology as applied to the contracting environment. The concept for the initial prototype/production applications were designed at ASD in the F-16 SPO's Directorate of Contracts. ICIS uses off-the-shelf imaging technology to reduce storage space, duplication costs, research time, and lost/misplaced documents.

The first application developed under ICIS is the Electronic File Cabinet (EFC) which was conceived and developed by the F-16 SPO's Directorate of Contracts. EFC is the basic storage system of ICIS and provides the main database.

The second application is called CORTS or Correspondence, Routing, Tracking and Suspense. CORTS, conceived and developed by the B-2 SPO's Contracts Directorate, provides the ability to take scanned images and route them for coordination, signature, or filing by various personnel on the system. EFC and CORTS form the heart of ICIS.

BEFORE ICIS

Conformed Contract. Maintaining a conformed contract[1] is not an easy task. Maintaining over 14 active contracts is even more difficult. The F-16 SPO averaged 863 contract actions (negotiations/definitizations) per year in the last 2 years[2]. The two oldest active contracts have over 1500 supplemental agreements (modifications), and the number is growing. The average contract has over 500 modifications. Add to these modifications hundreds of Procuring Contracting Officer Letters (PCOLs), plus a few Stop Work Orders (SWOs) and Notices of Deficiencies (NODs) every year. Clearly, maintaining control and order is in itself a full time task.

Conformed contracts are kept on every contract and at least one copy of every modification is kept in 3-ring notebooks. The contracts are kept current by inserting change pages, removing superseded pages, and adding new pages in the notebooks in accordance with the distributed modifications. A clerk receives two distributed copies, files one in the binder that contains the complete modifications, and takes the second copy apart to fill in the conformed contract. Due to the size of the conformed contracts, removed pages are not maintained and are tossed away. The audit trail of changes affected on a page is maintained only by the search through the binders that contain all the complete modifications. The conformed contracts, modifications, and correspondence alone occupy over 88 linear feet of shelfspace in the F-16 SPO's Directorate of Contracts.

Space is at a premium in the directorate. Boxes full of documents are found in and around the buyers' and clerks' cubicles because there is no more shelf or file space left in which to put them. As contract actions

are definitized and the files are sent to central archives in another building, more actions are waiting in the queue to take their place in the buyer's cubicle. PCOLs, NODs, and SWOs are kept in file cabinets for reference until closed out. The letters are filed in accordance to their contract and control number. These are the only records of the letters maintained by the directorate. Great care is taken not to lose or misplace the letters. However, "Murphy's Law" will rule that when the most important document is needed, it will be the one that is not in the file. Single copies of the conformed contracts and correspondence are handicaps since only one individual at a time can use them. If they are removed from their key location, others desiring to use them must wait their turn.

Document Logs. Logs are maintained to track and assign sequential numbers for each contract modification, PCOL, SWO, and NOD. As mentioned previously, the size of the F-16 SPO's contract history makes these logs very important. The manual logs can only be kept in single record books. This is necessary to avoid duplication of control numbers issued. The logs are used as references to research previous actions. By their nature, the paper logs cannot be used by more than one individual at a time. The logs were handwritten with extremely abbreviated narratives due to the space limitation of the form. This caused problems at a later time as users tried to use the subject line to locate a particular document. The condition of the logs reflects the influence of both the 50 plus individuals that have access every day, and the personnel changes over the 16 years since the SPO was created. Handwriting styles impact the usefulness of many entries. There was no quality control over the data. Experiences at reading the logs have been likened to reading hieroglyphics.

Research. Several times a week, actions, questions, or requests from management, audit agencies, congressional inquiries, or Freedom of Information Act requests are received by the Directorate. These requests necessitate trips to the archives to retrieve files for historical information, copies of documents, or for other uses. The researcher would most likely begin the search, if the exact modification number is not known, with a review of the modification logs. This would be a page by page search until the cryptic short titles revealed the most likely modification file, after which the file could be requested from the archives. In the case of the F-16 SPO, the location of the archives means a one-half hour round trip just to retrieve the file if it is readily available. Some F-16 SPO files are stored in off-site warehouses. Retrieval of these files can take up to 2 weeks. Time is also lost waiting in line to use the reproduction machine if copies of items from the file are needed. Another 15 minutes is required to return the file after its use. The current filing system in the archive department places file folders in a general location on giant rolling file cabinets. This system relies on human interface every time a file is stored or retrieved. This also leaves room for human error in the placement or recording of the location of the file folders.

The current system cannot tell the requester if the file is in or out before someone goes to look, nor can it tell a researcher if the particular document looked for is even in the file location. This leads to a lot of frustration and inefficient use of time researching the information an individual needs to do his/her job. Another problem is that files that are already checked out, misplaced, or missing when they are needed to support an ongoing activity. This can lead to delays or the decision to proceed with incomplete information.

Contract Files, Coordination and Review. In order to complete the definitization of a contract action, the buyer, with or without the assistance of a procurement clerk, must assemble the official government file. The official file has many sections. In the F-16 SPO, the AFSC form 3019[3] identifies which documents are in the file. The size of the file is influenced by the number of actions required to get the contract ready for definitization, the size of the contractor's proposal and other supporting documentation. Some files are one to four inches thick, while others taken together, may be over 14 feet in length. In the review process, prior to final signatures on the contract/modification, these files must be hand-carried through the review cycle. The files are moved from desk to desk, building to building, and in some cases, across the country to Headquarters Air Force Systems Command (AFSC) in Maryland. This is a laborious task that consumes the time of the buyers as they hustle the files to and fro. After definitization of the contract, the file must be carried over to contract files and copies made of the supplemental agreement for mailing.

Due to the questions that usually arise during the review process and the problems associated with retrieving files from the archives, buyers will make duplicate copies of key documents to maintain in their own "buyer's file" copy for future reference. This practice taxes already limited space in their cubicles and around the office, but is considered to be a worthwhile tradeoff to needing the information and not being able to get to it.

ICIS DEVELOPMENT

The Concept. In the Spring of 1989, discussions among buyers about a new technology called imaging created an interest in applying the technology to the contracting process. The application would encompass not only contract filing and storage, but the creation of a conformed contract integrating not only the modifications, but also the related correspondence. In addition, the processes of review and research would also be automated.

The Team. In order to develop an application that would benefit all the workers in the contracts directorate, a small cadre of seven individuals was formed to oversee the development of ICIS. The individuals represented each of the six branches[4] in the directorate. The composition of the team included procurement clerks, buyers, and Procuring Contracting Officers (PCOs), both military and civilian. The team was all volunteer and the work was carried out as an additional duty so as not to interfere with their primary responsibilities. This group formed the nucleus for ideas and ensured that as the software application was developed, all areas were considered and evaluated. After some research, a series of briefings ensued up the chain of command, culminating with a "live" demonstration of the basic capabilities of imaging technology to the directorate and the senior leadership of the SPO. After these briefings, the SPO Director gave the go ahead for the project.

Starting out. With the team established and authority granted to proceed, work began in earnest on the project. A modification to a current Air Force hardware/technical support contract was awarded to take advantage of outside expertise in imaging technology. With technical assistance secured, the next step in the development involved the interviewing of all the procurement clerks, PCOs, buyers, and secretaries in the directorate. The purpose of these interviews was to look at how and why the individuals performed their jobs and the interrelationship to each

other. A consolidated report on these interviews was presented to the team to verify what was heard in the interviews and clear up any misconception at the start. The third step was to diagram the interfaces and work flow involved in accomplishing the directorate's mission of contracting.

The interview process was important for two reasons. First, no matter how knowledgeable or well intentioned a small number of individuals are, they cannot paint a complete picture of how a unit functions with all its nuances. Secondly, the interview process began to develop a sense of "ownership" at the user level. The users remained a critical part of this development, and followup interviews were used at the end of the prototype and production application development. The purpose of the follow-up interviews was not to find out how good ICIS worked, but rather to find the flaws in the application and to solicit further suggestions.

A basic belief of the team was that nothing is perfect and everything evolves. The team members realized early on that the solution to a problem creates ideas for improvement on procedures not conceived prior to development. The ideas continue to come in.

Prototyping. The development of ICIS was difficult in that there were no other known imaging applications for contracting. Several iterations of the basic application were required before all the pieces fit together.

After initial briefings with great promises, previous automation initiatives failed due to delays in development of the application software and/or changes in technology. To prevent the same problems from occurring and to avoid a loss of momentum, a different approach to software development was taken.

Minimum documentation was provided up front and the majority of the resources were devoted to the development (programming) of the application. With no previous contract imaging applications to measure against, it was considered more important to develop a working prototype than to have a stack of paper explaining the theory behind the software development with no working application[5]. Using a method of software development known as "fast prototyping", the time between contract start and prototype completion was only four months. Because of concurrent design, development and testing, only nine months elapsed from original concept briefings to production implementation. In fast prototyping, as a module is completed, it is field tested by the future users of the application. The evaluation would ensure that the application did what it was supposed to do and recommended changes as necessary. There was pride in the ownership of the software; on the part of the eventual users, the focus remained on the goal to obtain an effective application.

During the initial software development period, it was learned that the B-2 SPO was also looking into the development of an imaging application and that was similar to the F-16 SPO's application. An agreement was reached between the two organizations to share their knowledge and experiences. To avoid duplication, the F-16 SPO dedicated its effort to developing what is now called the Electronic File Cabinet (EFC) portion of ICIS. The B-2 SPO's concentration would be in the development of an application to distribute, route, track and suspense image-based documents. This part of ICIS is known as the Correspondence, Routing, Tracking and Suspense (CORTS) System.

Programming of the EFC began in October 1989. By March 1990, a production version

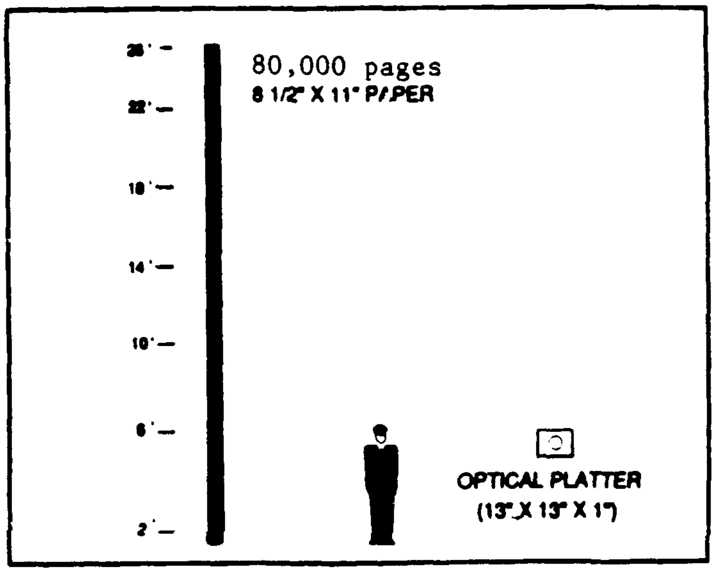
of the software was complete. Several enhancements have been added since March 1990 as a result of operating the application. Because of the close coordination with the B-2 SPO at the start of the project, the two applications are designed to dovetail together and operate as one integrated application.

HARDWARE/SOFTWARE REQUIREMENTS OF ICIS.

The following is not designed to be an all inclusive list of equipment, rather, it provides a basic look at the main hardware and software required to implement the ICIS application as used in the F-16 Contracts Directorate. Figure 1 on the next page shows the basic components of a WANG based imaging system[6].

Hardware and Memory. The"VS" shown in the middle of Figure 1 is a file/application server. In the F-16 SPO, this server is a Wang VS 5000 series minicomputer. The application server hosts the software necessary to run ICIS and controls the memory devices. The imaging software platform for ICIS is Wang Integrated Imaging System (WIIS)[7]. The Relational Data Base Management System (RDBMS) which stores the record location of the images is Wang Labs Professional Application and Creation Environment (PACE)[7]. The ICIS application will also operate on VS 100, 7000, 8000, and 10000 series Wang computer systems. Four 325 Megabyte (MB) hard drives provide 1.3 Gigabytes (GB) of usable magnetic memory for the F-16 SPO's application server. One drive is a dedicated host for the operating system software. The other drive hosts the ICIS application and acts as temporary storage for images being displayed. The third hosts the data base information and the fourth is currently a spare. The F-16 system uses two external Optical Disk (OD) drives to store images. Each drive contains a double sided 12" platter capable of storing 1.2 GB of information per side (for a total of 4.8 GB of on-line optical storage capacity). The two optical disks can store, as images, over 80,000 paper pages as illustrated by Figure 2 below.

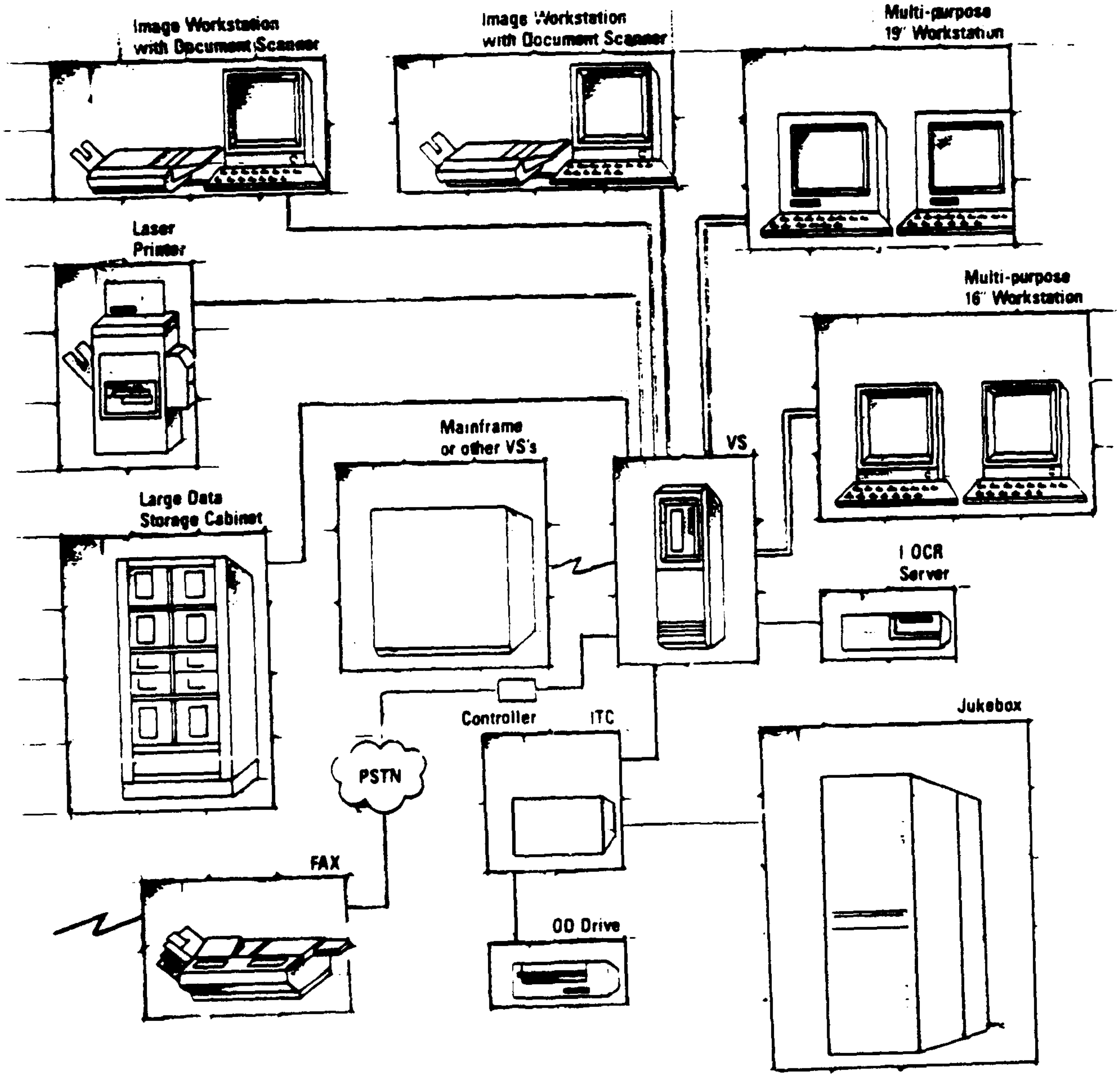
Fig 2 Storage Volume Relationships



Based on current usage, in the F-16 SPO's Contracts Directorate, additional platters and/or optical drives will be required in one year. One option under consideration is the addition of an optical jukebox. Jukeboxes can store 50 or more platters and uses robotics to retrieve the platters as requested; similar to a record jukebox machine. But, unlike a record player, the image jukebox may have two or more drives in action simultaneously and only "plays" the platter for a few seconds, long enough to retrieve the image, and then it restores the platter to its shelf. A jukebox properly configured would allow access to 1 million or more document images.

The LAN. At present, due to the older dual coaxial cable Local Area Network (LAN) installed in the F-16 SPO, the display of

Fig 1 Wang VS based Imaging System Configuration



Source: Publication <u>WANG-ON-IMAGING</u>

images is limited to workstations equipped with 16" VGA monitors (see Figure 1) within the contracts directorate. The 16" monitors are attached to AT class PC's. However, in the Spring of 1991 the F-16 SPO will upgrade the LAN to an 802.3 thinnet system. At that time, using a product called PCLAN/VS Windows[8], ICIS will be accessible to all SPO personnel with access to the LAN.

Monitors and PCs. Displaying images over the new LAN will require an AT class PC with EGA or higher resolution 14" color/monochrome monitors and Microsoft Windows[9] version 2.10 or higher. The 14" color monitors can display approximately 60% of an 8 1/2" x 11" document at any one time. The use of 16" monitors allows the display of one full size 8 1/2" x 11" imaged document or 2 half size windowed documents. The 19" monitors allow the side by side display of two full size imaged documents, or four half size images allowing the review and comparison of four separate documents or four parts of the same document simultaneously. The displayed images on any of the above terminals may be enhanced by viewing a smaller portion of the document while magnifying it. The 19" monitor is useful for those who will do document/contract file review. It is also ideal for use at scanning stations.

Scanning Stations. Scanning stations are comprised of a document scanner slaved to an AT class PC with a 16" or 19" monitor. Although document scanners closely resemble desk-top copiers, a fundamental difference is that no additional paper copies are created. The scanners can be equipped with sheet feeders that handle up to 50 pages. There are two scanning stations in the F-16 SPO's Contracts Directorate. Through these scanning stations, documents enter the system, are indexed as much as possible, and then are filed/routed/distributed for further action.

Printers. Although the goal of ICIS is to create a paperless environment for contracting, paper copies can be printed of images and database information at any time. The printing of images requires a graphics capable laser printer. The printer may be part of the LAN or a dedicated system printer.

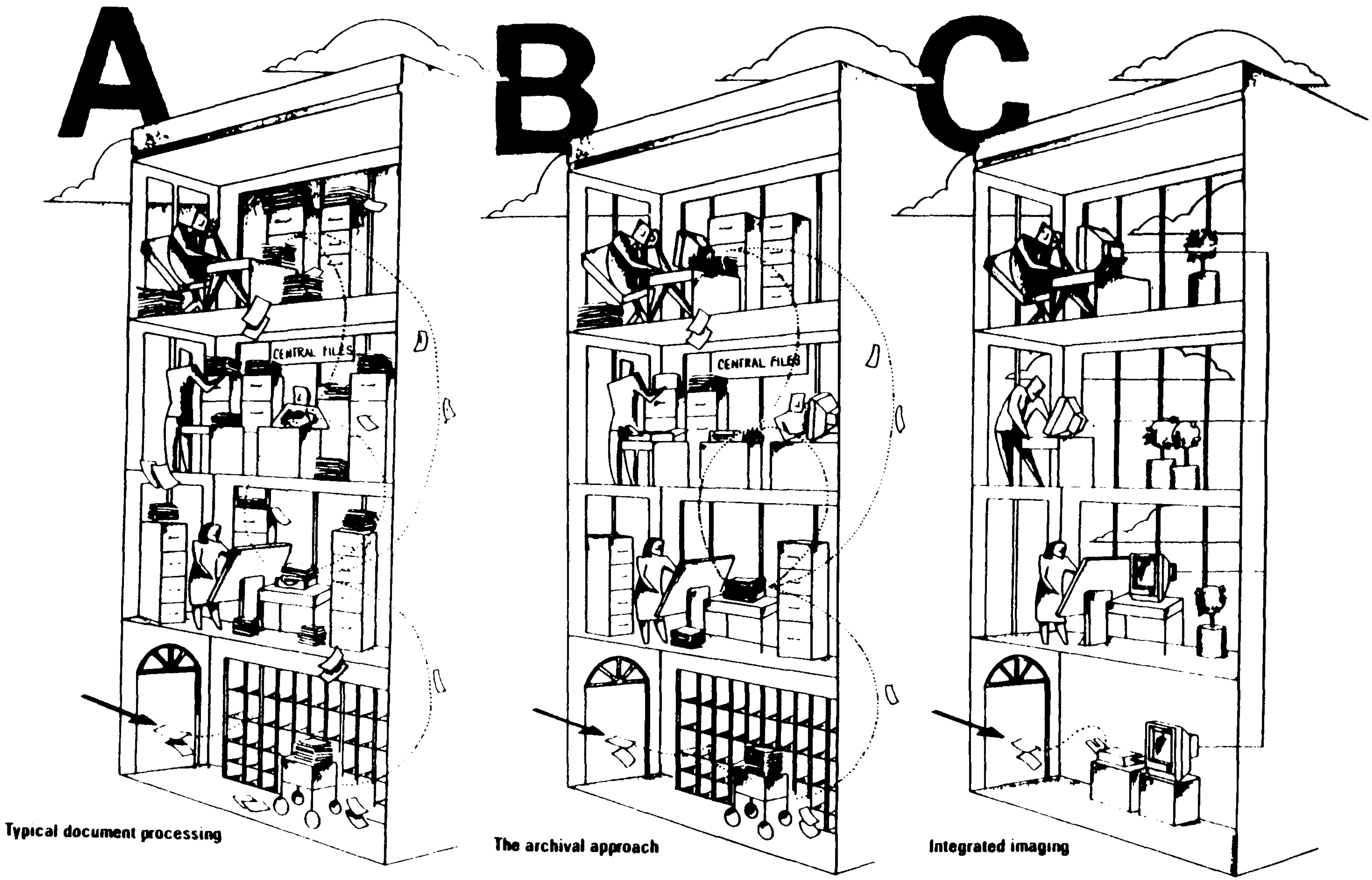
Optical Character Reader. The F-16 SPO's system also has an Intelligent Optical Character Reader (I/OCR) device, which converts scanned images to ASCII text for word processing or full text word searches. This process can be automatic or user initiated.

CONTRACTING WITH ICIS

On any given day, a massive amount of paperwork flows into and through a program office. The two main areas that ICIS was developed to handle are general correspondence and contract files. The following discussion looks at contracting using the EFC and CORTS applications and the solutions to the manual process.

How does contracting with ICIS work? Figure 3 on the following page shows three different office environments[6]. Office A represents an office with no automation applications such as the F-16 SPO in the late 1970's. Documents come into the directorate mail box for manual distribution to individuals. The individuals will make photocopies as needed to further disseminate the information or to complete files. Filing requires recording receipt of the document, the filing location, and the physical act of punching holes and placing in a file folder(s). All documents are created using typewriters. Duplicates are kept for record and as examples. Documents can be mis-

Fig 3



Source: Publication WANG-ON-IMAGING

placed, misfiled, or lost under the mountain of paper in the environment

Office B, representative of the F-16 SPO's Contract Directorate in the 1980's, shows some automation in the process such as net worked word processing, spreadsheets, and database packages. Internally generated documents and statistics can be stored on floppy disks or in the computers memory, and shared with others on the network. However, paper work still flows through the office manually with the resulting time delays and desk clutter.

Office C represents the most efficient use of automation and imaging reflecting the full implementation of ICIS. Documents entering the mail room are scanned, indexed, routed or filed electronically as images in accordance with established office policy. This is where the F-16 SPO's Contracts Directorate will be by the end of 1991 with the installation of the 802.3 LAN.

EFC. The Electronic File Cabinet was created to automate the archive and research processes. The main functions of the EFC are log management, filing, research and conformed contract and each will be discussed in this section.

Log Management. Log management is an essential element to the EFC which serves as the primary source for the data base. Logs reserve sequential numbers for present or future use in controlling modifications, PCOLs, NODs, and SWOs. In order to maintain quality control and keep the application user-friendly, the screens have preformatted fields to be filled in. In addition, many of the routine fields such as document type (for example, modification or PCOL), contract number, and contracting officer, have pick lists that are filled in by selecting a function key and then placing the curser opposite the selected choice and pressing the return key. The fields are then populated with this information; the only manual input task is the typing of the subject matter. To prevent the users from forgetting this or any other step, the computer will not reserve/assign the sequential number until all the fields are filled in properly. The logs are multi-user. As discussed earlier, they can be accessed by all users simultaneously for research as well as for the assignment of control numbers without duplication. This improves on the manual system by adding quality control, removing hieroglyphics handwriting, achieving greater legibility and increasing information flow.

Filing. The central goal to the creation of the EFC was the storage of all the paper documents in the most efficient manner. For long term storage, the archive process is similar to that used for microfiche. Imaging, however, allow a faster more efficient method for tracking and retrieving files than microfiche. The contract filing portion uses index screens to record the location of such documents in the contract file as well as each piece of controlled correspondence (PCOLs, NODs, SWOs). The controlled correspondence is filed under a section aptly named "correspondence". When these documents are scanned, the indexes are captured from the logs by a single step of matching the image displayed with the log index by marking the index with an "X" in the left hand column. This avoids a step of rekeying the information used to reserve the control number.

For contract files, the process is similar to the correspondence but further sub-divided to include the basic contract, sections and sub-sections of the contract, modifications to the basic contract and their sections and subsections, as well as the contract file itself, the tabs and subtabs of the files for the basic

contract and subsequent modifications as based on the AFSC Form 3019. As each contract page is scanned, it is indexed with the information. It includes identifying the section and even the individual Contract Line Item Numbers (CLINs), Accounting Classification Reference Numbers (ACRNs), Contract Data Requirement List (CDRLs), and the contract clauses, and special provisions.

Documents are scanned and indexed/recorded by contract number, modification number, subject description, and by the contract file tab under which it will be located. For example: Acquisition Plans are filed under Tab #2 of the contract file. The individual pages are not indexed on documents for the file unless required for immediate reference. This reduces the scanning and index time as a proficient individual at moderate speed can complete an index screen in less than one minute and the scanners in the directorate can scan at a rate of 30 pages a minute.

A batch scanning process is one of the enhancements added after initial development. Batch scanning allows many documents to be scanned separately from indexing. This indexing can be accomplished later at a different terminal if desired by matching indexes created in advance of or subsequent to scanning. It should be noted that an image may have more than one index associated with it. For example, a Section B page may have three or more CLINs each being separately identifiable. With all the database information provided by indexing, research time is significantly reduced.

Research. Research time via ICIS is reduced from measurement in days and hours, to minutes and seconds; the information will never be farther away than a personal computer. Because ICIS has multi-access capability, researchers will never receive a file busy indicator. Using an inverted pyramid theory, the user is assisted in locating the file or document needed by answering questions on a query screen. Figure 4 on the following page is an example of a query screen for researching contracts and/or modifications. Any or all of the questions may be answered. The more the users knows about the research subject, the fewer unlikely alternatives they will get. The search can be as broad as all the contracts in the SPO, or a single specific page to a letter in a contract file folder under a specific tab.

Because of the level of information provided in the indexing of documents and contracts, an item as small as CLIN 0001 to a contract can be located in six seconds. And for a contract closeout, all the CLIN 0001s can be identified in all the modifications to the contract in about six seconds. This is far superior to digging through boxes of information page by page. The search process in the relational data base uses Words In Text (WIT) fields looking for all occurrences of the information provided. A search for correspondence related to a contract document search is only a keystroke away.

Under the manual system, even if the exact letter in a folder under the exact file tab was known, it would take a 10 minute walk, 5 minutes to fill out the request and to pull the file, at least 5 minutes to take the page to the nearest reproduction machine to make a copy (if no one is ahead of them in line) and a 10 minute walk back to their desk. Under ICIS, the request would take 1 minute for a very slow typist, 6 seconds for the computer to retrieve and display the image on their PC from optical storage, and another 6 seconds to print the page to a laser printer located in close proximity to their desk (if a hard copy was needed). Alternatively, research information from their desk monitor could be obtained.

FIG 4

```
                                  Friday  November 16, 1990           2:02 PM

                          CONTRACTS & MODIFICATIONS
------------------------------------------------------------------------------
Contract Number: F33657 - ?* - ? - ?***  Modification Number: ?*****

Effective Date:  ?********************   Mailing Date:  ?********************

Description*:
?************************************************************************

Buyer Code:         ?**

PCO Code:           ?**

Obligated Amount:   ?***************

------------------------------------------------------------------------------
Enter) List Contracts & Modifications
1) Query Section Information

4) Clear /All                          7) Saved Queries
                                                              16) Return
```

SOURCE: F-16 SPO ICIS USER'S MANUAL

Another disadvantage of the manual system is miscommunication. If the wrong file is pulled from a decentralized archive location and the error is not detected until the file is on their desk, the research time is doubled. The same can happen with a wrong key stroke on an image, however, an extra minute is less time consumed than an extra half-hour.

Conformed Contracts. Because of the rationale data base used with ICIS, the conformed contracts are created/modified with the addition of the scanned image to the data base. When a query is made of the contract data base, all indexed images matching the query appear. Figure 5 on the next page is an example of a list of contract modifications under the conformed contract portion of the EFC. Note that by using function keys, display, printing or sending of an image or images can be accomplished.

Also related sections, correspondence, DACOMs (data communication - used by the B-2 SPO), or contract file items can be accessed immediately from this screen.

Contracting using CORTS. The development of CORTS allows for the movement of imaged documents across the directorate and, with the completion of the LAN, across the SPO. When new documents come in, they are scanned and then routed to the appropriate individual(s) or groups. Even unaddressed documents can be routed based on established office policy. Documents do not have to be indexed if the clerk is not sure of the documents status. Instead, the documents can be routed to the buyer, contracting officer or branch chief for disposition. The eventual user of the document will properly index the document and file it appropriately in the electronic contract file.
How many times have individuals been on

FIG 5

Friday November 16, 1990 2:02 PM

CONFORMED CONTRACT

	Contract	Mod	PCO	Buyer	Mailing Date	Description
*	F33657 82 C 2120	PK0001	A18	A18	09/09/1990	FIRST MODIFICATION FOR
*	F33657 84 C 0247	BASIC	A2P	A2P		BLOCK 50 DEVELOPMENT
*	F33657 84 C 0247	P00001		A18		THIS IS A TEST OF MODI
*	F33657 86 C 0123	P00029	A3F	ATF	07/17/1990	DEFINITIZATION OF CCP
*	F33657 88 C 0037	P00037	A51	AQB	06/20/1990	INCORPORATION OF ECP 1
*	F33657 88 C 0037	P00034	A58	AKC	05/09/1990	INCORPORATION OF ECP 1
*	F33657 88 C 0037	P00031	A51	AQB	05/07/1990	INCORPORATION OF ECP 1
*	F33657 88 C 0037	P00028	A3K	AEW	04/12/1990	INCORPORATION OF CLAUS
*	F33657 88 C 0037	P00015	A3F	AAF	04/11/1990	INCORPORATION OF ADDIT
*	F33657 88 C 0037	P00017	A58	AKC	04/03/1990	MYIII LONG LEAD EXTENS
*	F33657 88 C 0037	P00026	ANJ	A18	03/29/1990	INCORPORATION OF CDRL
*	F33657 88 C 0037	P00032	A58	AKC	03/29/1990	INCORPORATION OF CCP 4

Enter) Display Indices
25) List Related Sections
2) Mark /Clear 11) Display Image 26) List Related Correspondence
4) Prev /First 12) Print Image 27) List Related DACOMS 15) Output
5) Next /Last 13) Send Image 28) List Related Contract File 16) Return

SOURCE: F-16 SPO ICIS USER'S MANUAL

the end of routing slip and received bulletins and other information pertinent to events that happened yesterday? By using erasable magnetic storage, daily bulletins and other "information" can be imaged for distribution to all personnel simultaneously, thereby saving reproduction time, another paper on the desk, and items being overcome by events. To avoid wasting optical storage, these information documents would be stored in magnetic memory.

Coordination. Documents requiring coordination for record can be routed via ICIS using CORTs. Priority interrupts and other flags can be used in this system to call attention to projects requiring subordinates to take immediate action. Time is saved by not physically moving the document. This prevents it from being lost, routed improperly, or placed at the bottom of the in-basket. The tracking feature, as previously mentioned, saves time in looking for and/or guessing the current status of a document in coordination or under suspense. At a push of a function key, the history of the file is displayed showing where it is, where it is going, and where it has been. The record of approval/disapproval and current suspense is also displayed as a computer created cover sheet to the document.

The correspondence coming into the office can be batch scanned at a central location allowing the immediate dissemination of the documents via CORTs to individuals addressed on the document. CORTs has both preselected distribution and unique (manual input) distribution networks. The advantage of imaging allows the distribution of multiple copies of the document to several individuals electronically. This avoids extensive photocopying of documents and the delay

inherent in using traditional mail box routing.

Individuals receiving correspondence in CORTS through their electronic mail can display, browse the document, then take action. The action may involve handling the document, continuing to route it to additional individuals for information purposes or prompt further action with a suspense. The correspondence maybe attached to the official contract file for archive purposes or any combination of the above. For instance, an engineering change proposal (ECP) for new work that has not been assigned to a buyer can be routed to the branch chief. The branch chief could then send it to the assigned contracting officer or buyer. The document would then be identified as part of the official government file using EFC. An electronic copy is also sent to the appropriate Office of Primary Responsibility (OPR) for technical review with a cover letter generated in word processing and attached at routing transmission. The OPR could then review the document on-line, or select sections for printed hard copy. The OPR can respond by internal E-Mail or package of E-Mail and word processing document. This response would then be added to the official file using EFC to Tab #26 technical review. Thus completing a cycle in this example.

In the future we hope to be able to innovate a coordination cycle of CORTs which would allow the use of Electronic Approval/Disapproval to be registered on the imaged document as it is routed on its way through various levels of approval within a directorate or across directorates.

SAVINGS

Duplication costs are avoided through the use of the EFC and CORTS. In duplication there are two costs. One is the obvious budget items of power, rental, paper and Maintenance. The second hidden cost is the lost productivity as clerical and professionals stand in line waiting for a large number of copies to be run. When one or more copier machines break down, as they frequently do at the most inopportune times, this hidden cost climbs rapidly as well as does employee temperaments. By reducing the number of copies created, a savings is realized in personnel time, paper resources, speed of information distribution, and wear and tear on copier machine utilities.

An independent study performed by the Propulsion SPO looking at the cost benefits of implementing ICIS estimated an annual savings of $163,849 over the current manual process. The study was based on 63 person contracts directorate, similar in size to the F-16 contracts directorate. Conservative estimates on filing, research, copying distribution can be reduced by 90.9 (10%) to 181.8 (20%) hours per month and may go as high as 272.7 (30%) hours per month. Based on the 20% figure a two year savings based on reduced manpower would be $228,048. The estimated reduction in bond paper consumption would be $8,075 per year. Usage for remaining copies not eliminated by ICIS would be 41% of current usage. The savings in this area, taking into account the maintenance cost of the image scanner, is $36,944 per year at 3.8 cents per page for copier maintenance. The reduction in paper copies will increase the life cycle of the copier machines from five to eight years and will result in deferred expenditures not calculated here. Furthermore, mail time for documents will be reduced from an average of two days between SPO directorates to seconds using images instead of paper.

The estimated savings for five years is $819,245. The implementation costs for a

system similar to the one in the F-16 SPO's Contracts Directorate would be approximately $210,000, including the cost of a VS 5000 computer. Even with this investment the payback period for ICIS is projected to be less than two years. If a compatible computer system as previously described is already in place, the pay back period would be shorter.

CONCLUSION

ICIS is the first paperless contracting system. It is successful because it was developed by the users. The implementation of ICIS has a rapid payback period of less than two years. The transition to a paperless system takes a small adjustment period and people should be allowed to become comfortable with the system.

As mentioned earlier in this paper, ICIS continues to be refined. With the deployment of the production versions of the EFC and CORTS, in the F-16 SPO and other SPOs', more improvements to the acquisition process are being considered for implementation. Below are some current projects under way to take advantage of imaging technology.

Future ICIS Projects. Future projects with ICIS involve more coordination with agencies external to the F-16 SPO. They include the development of paperless contracts and proposals. Currently the contract writing system for AFSC is being upgraded to a forth generation RDBMS. And as a result, the system will be modifiable to provide indexing for contract cover pages, CLINs, delivery schedules and fund cites. This will expedite the scanning of contract pages by streamlining the indexing process. Under consideration is a process that will electronically create and store contract documents in ICIS, thereby deleting the requirement to create and scan contract pages. The cover page will still require original signatures and be scanned into the system at contract award. This is more a procedural issue then a technological one. Documents stored in ASCII form are one-tenth the size of a scanned image significantly increasing the number of documents that can be stored on one platter.

In addition, our prime contractors are in various levels of development of electronic proposal preparation programs that will interface with the ICIS application.

At present, proposals are too labor intensive to scan at the SPO and only the letter of transmittal is scanned to serve as a record that a proposal has been received.

In the very near future, joint efforts with our prime contractors will provide the ability to handle proposals created and stored on reusable optical platters at the contractor's facility. These optical platters will be mailed to the SPO along with a record copy of the document for the "official hard copy file". It is envisioned that the Defense Plant Representative Office (DPRO) will have access to the proposal via the contractor's computer system to allow on-line review of the proposal. Hard copy pages can be generated by users for those sections that require hands-on manipulation.

This joint effort between the SPO and our contractors will involve providing the contractors with rent-free use of the ICIS software application. In addition to saving the contractor the up-front cost of developing their own software application, the program also gains the savings from the reduction in overhead expenses. These savings will come from the reduction in the number of printed copies, handling, wear and tear on reproduction machines and postage.

The proposal on optical disk from the contractor will then be transferred onto the SPO system and copied to a WORM (Write Once Read Many) optical platters thereby making it an unalterable and permanent record. The proposal will then be available for review by all individuals with authorized access via their personal work stations. No additional copies are required of the completed proposal. This saves space in cramped office environment from copies of proposals that range from 100 to many thousands of pages, For those individuals that need copies for traditional manual review, the capability will exist as it does presently to print the pages they need instead of the whole proposal. When the review is complete, they can toss the pages out when done because they always have access to originals. (Most people hold onto copies from past efforts just in case they need them to refer back to later. only to continue to tax their limited storage space.)

In conclusion. it is clear that ICIS is the future in contract management and administration. It gets the paper off the desk and out of the vaulted archives and puts it in instant reach of the users. It provides a more efficient way to store and move files and documents. It increases productivity through reduction of non-productive lead time waiting for or searching for information. ICIS creates a true on line conformed contract. ICIS saves space and time. With the use of the Electronic File Cabinet and the Correspondence Routing and Tracking System, the F-16 SPO is moving into the 21st Century and away from the paper laden desks of the 20th Century. This system is an effective and efficient way to manage information. ICIS is paperless contracting and a part of the paperless office of tomorrow in use today.

BIBLIOGRAPHY/ENDNOTES

1/ A conformed contract is a hard copy of the basic contract and the accumulation of all the changes to the basic contract by subsequent modifications, through the use of change pages.

2/ January 1991 F-16 SPO Functional Management Review.

3/ The AFSC Form 3019 titled Contract File Checklist provides an established format for the placement of documents in the contract file folder. Prescribed items, called Tab(s) are numbered 1-67. Additional numbers are added as needed.

4/ Branches are the lowest supervisory level organizations within the F-16 Directorate of Contracts.

5/ All documentation was provided at completion of the production application.

6/ WANG-ON-IMAGING. Lowell MA: WANG Laboratories, Inc. (1989)

7/ WIIS and PACE are a trademark of WANG Laboratories, Inc.

8/ PCLAN/VS Windows is a product of WANG Laboratories, Inc.

9/ Microsoft Windows and MS Windows are trademarks of Microsoft Corporation.

EXPERT SYSTEMS APPLICATIONS IN THE PROCUREMENT FIELD

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ABSTRACT

This paper focuses on how the technology of artificial intelligence can be used to help contract managers improve their decision-making performance. This is an especially timely topic since many contract managers are unsure of how to apply emerging Expert Systems and Decision Support Systems technology. Discussed are the applications of Expert and Decision Support Systems to contract management functions such as:

- Source selection, i.e., making "best value" decisions;
- Warranty cost-benefit analysis;
- Acquisition Scheduling; and
- Statement of Work preparation.

Discussed are real-world examples of where Expert and Decision Support Systems have helped, both industry and Government, contract managers improve their decision-making performance. For example decision support systems (DSS) are being used for the source selection of high-dollar value and complex systems.

Computerized Expert Systems could have the long-term effect of significantly changing the thought process behind the structuring, awarding, and administering of contracts. The limits of Expert System applications for contracting lie only in the imaginations of their creators.

INTRODUCTION

Success in the contract management profession is based on being efficient and effective. This is true whether the organization is a private company or a Government agency. There are currently many procurement automation support products designed to improve efficiency, e.g., electronic data interchange, imaging, automated FAR, and computerized vendor source lists. However, there is a distinct lack of automation tools for the higher level decision-making situations faced by many contract managers, e.g., source selection. This research paper discusses how these higher level automation tools can be efficiently and effectively integrated into the contract management process.

This paper discusses the emerging technology of Expert and Decision Support Systems and how it can be effectively applied to the contract management process. Expert systems are relatively new types of automation tools. These tools specifically target improving the effectiveness of the decision-making function. They can be used at the operating/line-level as well as for strategic decisions. The need for Expert and Decision Support Systems will increase in the Government procurement field due to the following factors:

- The complexity of the regulatory environment will continue to increase due to frequent changes to the Federal Acquisition Regulation (FAR) and its agency supplements;

- The technical nature and complexity of the items and services to be purchased will also increase, e.g., sophisticated consulting, advanced hardware, etc.;

- There will be fewer human resources with which to perform the contract management function. This factor is compounded by low experience levels and high personnel turnover in the acquisition work force;

- The emphasis on making "best value" purchasing decisions, as opposed to always awarding to the low bidder, will increase as the Government attempts go obtain more value for its money; and

- The pervasive nature of protests, which can significantly delay procurements as well as create additional workload for contracting officers, will force the Government to adopt a more defensible

method of source selection, especially for complex procurements.

The overall result of the above factors is the scope and complexity of Government contracting will constantly be increasing. Government contracting officers and the contract specialists supporting them will be faced with working in an ever-increasing demanding procurement environment. Expert and Decision support systems can help contract managers to meet these challenges as well as providing them an effective means to leverage their resources.

The objective of this paper is to provide an overview of available technology, discuss its practical uses, and finally examine its impact on contract managers, at all levels. To that end, this paper will provide a definition of what Expert and Decision Support Systems are, discuss how they are used, and project where the technology is headed. Emphasis is placed on practical applications, as opposed to theoretical constructs.

DEFINITION OF EXPERT AND DECISION SUPPORT SYSTEMS

An Emerging Technology. Expert Systems are defined as a computerized knowledge base of basic facts and heuristic knowledge that is able to eliminate infeasible decision options up front. The term originated since Expert Systems can perform in a similar manner to human expert counterparts, e.g., suggest ways to solve complex problems and/or make predictions. Professor Edward Feigenbaum, a leading expert system researcher, provides the following definition:

> . . . an intelligent computer program that uses knowledge and inference procedures to solve problems difficult enough to require significant human expertise for their solution. Knowledge necessary to perform at such a level, plus the inference procedures used, can be thought of as a model of the expertise of the best practitioners of the field.
>
> The knowledge of an expert system consists of facts and heuristics. The "facts" constitute a body of information that is widely shared, publicly available, and generally agreed upon by experts in a field. The "heuristics" are mostly private, little-discussed rules of good judgment (rules of plausible reasoning, rules of good guessing) that characterize expert-level decisions making in the field. The performance level of an expert system is primarily a function of the size and the quality of a knowledge base it possesses. (1)

AI Expert amplifies the discussion on the "basic facts" portion by noting: "Conventional systems contain minimal knowledge and loads of data while expert systems process gobs of knowledge and perhaps even gobs of data." (2) Likewise "heuristic or experience-based knowledge lacks a crisp, mathematical relationship structure but requires explicit definitions by a set of elementary rules." (3)

The heart of an Expert System is the inference engine. This device controls all the functions of the expert system. The inference engine performs the reasoning function by integrating and analyzing the knowledge contained in the basic facts and heuristics parts of the expert system. Two of the most noticeable outputs of the inference engine are the questions the expert systems poses to the user and the advice given by the system. A more formal definition of the function of the inference engine is provided by AI Expert:

> Inference-engine functions include deciding what to do next, scheduling competing tasks (a managerial role), and applying expert knowledge to solve pieces of the problem (a practitioner role). (4)

The area of Expert Systems is a subfield of artificial intelligence (AI). The AI field originated in late 1950s but had to wait until the 1980s for computers with enough power for effective implementation. Expert Systems differ significantly from tradition computer

applications. Traditional computer applications, e.g., spreadsheets, use highly structured algorithms, or sets of instructions, to perform specified tasks such as cost/price analysis on electronic spreadsheets. The algorithm has no flexibility beyond its design parameters. Expert or decision support system also use algorithms however these can be expanded to accommodate a variety of information. This gives them the ability to generate new algorithms to solve problems. Key differences between AI and traditional computer applications are described below:

> "AI differs from traditional computer science in two major aspects. First, rather than using the traditional programming languages of FORTRAN and BASIC, it employs a language such as LISP which is capable of processing symbols, words, phrases, complicated formulas, and numbers. Second, AI programs do not necessarily solve problems by performing sequential calculations. Rather they take logical shortcuts - or 'symbolic inferences' - essentially *common sense reasoning.* (5)

It is important to note an Expert System has a special purpose intelligence, usually for a particular functional area. Expert Systems solve problems by interviewing a user, in a manner similar to the way a human expert would. Entire lines of inquiry are eliminated if a proper questioning strategy is used, leading to a correct solution.

Decision Support Systems. A Decision Support System (DSS) is a type of Expert System. A DSS, unlike an Expert System, does not have a pre-established knowledge base. This means a user must develop their own knowledge base. Like Expert Systems, Decision Support Systems have been successfully used for improving the decision-making performance of managers in a variety of situations. In the procurement field, Decision Support Systems are used to help buyers make "best value" source selection decisions; this is discussed in more detail later on. It is important to note a DSS is used where it might be impractical to develop a true Expert System. The list below illustrates this point and provides a basis of comparison between Expert and Decision Support Systems.

<u>Decision Support System</u>

- User must develop knowledge base
- For high-level one-of-a-kind type problems
- Prototyping per se not required
- Wide applications
- Can handle a variety of tasks
- Very flexible
- May contain an Expert System

<u>Expert System</u>

- Pre-established knowledge base
- For high-volume repetitive problems
- Prototyping required
- Narrow applications due to a specialized database
- Task must be well-bounded
- Limited flexibility

Expert System Shells. These are essentially self-help Expert Systems kits. Shells are especially useful for users who have a low level of knowledge about AI technology but who want to build a knowledge-based system for their own applications. A large variety of commercially-available shells have been developed, each with varying knowledge models. Expert System shells are the predominant development tool used today. These shells commonly use the LISP, PROLOG, and C computer languages.

An example of an Expert System shell is "CommonKnowledge" from WANG Laboratories. This product, like other expert system shells, allows a user to capture the knowledge of a human subject-area expert and create their own knowledge base without any prior knowledge of AI techniques. CommonKnowledge consists of four functional parts:

> **A user interface** -- Provides a standard interface for running a variety of knowledge bases.

An inference engine -- Controls how the knowledge base is used to reason toward a solution to a problem or draw a conclusion about a particular set of circumstances.

An explanation facility -- Allows the user to explore the reasoning process, examine values, and ask why certain knowledge was used in solving a problem and how different pieces of knowledge were used to solve a problem.

A knowledge acquisition facility -- A unique facility that guides you in using your expertise to build an application. (6)

There are several benefits associated with using an Expert System shell. First, using a shells allows faster and easier development since the user starts with a framework. Second, use of a shell saves money that would have otherwise been spent developing original computer software. Third, the shells have a proven record of successful use. Fourth, most shells are designed to operate on personal computers, as opposed to mainframes, which significantly reduces their operating costs.

However there are some disadvantages to using shells. AI Expert discusses some of the drawbacks associated with current Expert System shell products: 1) a heavy demand is put on users since they must learn how to use several knowledge-representation schemes, interconnection of shells is difficult due to the lack of commonality, and this complicates administration tasks. Competitive pressure is the main reason for the lack of standardization and connectivity between shells. Vendors, in an effort to differentiate their products and maintain a competitive advantages over their competitors, discourage the adoption of a universal standard. (7) The different knowledge representation schemes puts a heavy demand on users to learn each of them. This frustrates efficient solutions for interconnecting and administering different knowledge bases.

EXPERT SYSTEMS IN GOVERNMENT CONTRACTING

The Procurement Environment. The Government contracting environment is composed of an extremely complex legal, regulatory, and procedural framework. It can take years to properly train a contracting officer (or their private industry equivalents) to a level where they can perform efficiently and effectively on their own. The body of knowledge concerning Government contracting is so broad that few people master all its various facets. As a practical matter, many procurement personnel specialize in a particular area, e.g, buying or contract administration.

Due to the heavy demands placed on human subject-area contracting experts, the use of expert systems offers a cost-effective way to capture and distribute their knowledge about key functional areas, e.g., terminations, claims, warranties, contract closeout, financing, cost allowability, and labor laws. Properly designed and implemented expert systems offer the following advantages to professionals in Government contracting: 1) more accurate and timely decision making; 2) increased productivity; 3) improved quality of solicitations and contract modifications; 4) enhanced ability to monitor and assess contract performance; and 5) a relatively inexpensive way to preserves critical knowledge possessed by a human expert. The overall benefit of using expert system is improve the service level provided to internal, requirements-generating organizational customers, e.g., engineers, technical officers, or program managers.

Using Expert of Decision Support Systems forces the requirements-generating and contracting office personnel to clearly state their needs. This is a crucial first step since the requirements of many solicitations are not finalized when the solicitation is issued and sometimes not until after the contract is awarded. Typical procurement-related situations where Expert and Decision Support System can help are listed below:

- What proposal offers the "best value?"
- Is the warranty cost effective?
- Should our company bid on this RFP?
- What is the most cost-effective shipping method?

Expert systems, when properly used, offer more consistency in the decision-making process. This is an especially important consideration given the increased frequency of protests and claims. Expert Systems help by eliminating infeasible decision-making alternatives up front, e.g., ruling out a fixed price contract as a vehicle for research and development work. The result, is a reduced Procurement and Administrative Leadtime (PALT) time and reduced effort, which allows for more time to perform other tasks such as training. For small businesses using an Expert System is far less expensive than hiring a full-time human expert or even a part-time consultant.

Expert Systems are an excellent training aid for a contracting office. They can help turn novices into experts by providing an individually paced learning program during training. Expert Systems also serve as a ready and authoritative reference for a particular subject area. The use of Expert Systems for training fills an essential need, especially within the Government given the frequent need to retrain due to high turnover of Government contracting personnel.

EXAMPLES OF APPLICATIONS

Practical applications of Expert and Decision Support Systems use in Government contracting are limited. The following examples, discussed below, illustrate the types of situations where these systems can be effectively used. The reader should note, it is beyond the scope of this paper to discuss the detailed workings of each of the example applications. Rather, a functional overview is provided with a discussion of the benefits offered with using an Expert or Decision Support System in each situation.

SOURCE SELECTION. Use of a Decision Support system helps reduce costly and time-consuming errors caused by the inability of humans to mentally process a large volume of data at once. These considerations are especially important in the source selection process where a "best value" decision must be made. For the purposes of this paper, best value is defined as making the optimum tradeoff between price and performance factors during a source selection. As stated below, the Federal Acquisition Regulation (FAR) specifically encourages best value buying.

> While the lowest price or lowest total cost to the Government is properly the deciding factor in many source selections, in certain acquisitions the Government may select the source whose proposal offers the greatest value to the Government in terms performance and other factors. This may be the case, for example, in the acquisition of research and development or professional services, or when cost-reimbursement contracting is provided." (8)

However the practical implementation of this concept is very difficult. The FAR provides no real specific guidance on how to accomplish the detailed procedures in structuring a best value source selection plan such as selecting and weighting various evaluation factors. Various Federal agencies use a variety of source selection procedures such as color coding (a qualitative system) or numeric scoring (a quantitative approach). However, these type of scoring systems do not integrate the best features of qualitative and quantitative systems. Worse yet, these proposal scoring systems are implemented manually which can require significant amounts of time and personnel support and the results can vary from person to person (leaving fertile ground for protests). This leaves Government buyers in a difficult predicament. The lack of effective quantitative and qualitative tools leaves the buyer, more often than not, in the situation where the lowest price, as opposed to the best value, is the deciding criteria for contract award.

Decision Support Systems are ideally suited to handle complex problems such as making a best value decision among competing

proposals. This occurs since a computer-based DSS can remember and process problems involving combinations, e.g., selection and weighting of evaluation factors, much more efficiently than a human being. As a practical matter, the cognitive capacity of most people is limited; they can mentally process only about seven items at one time. This is an important consideration since a major source selection can involve scores of evaluation factors. Another benefit of using a DSS for best value source selection decisions is it provides an objective viewpoint. Use of a DSS results in the following benefits to a buying office: 1) all alternatives are considered; 2) the ability to perform rapid and cost-effective evaluation of "what if" situations, e.g. changing weights of various evaluation factors; 3) automatic documentation of the source selection decision occurs as a by-product of system use; and 4) reduced exposure to protests.

Analytic Hierarchy Process (AHP). Curtis Cook, a leading researcher in the area of applying DSS technology to federal procurements, makes the following observations regarding source selection: "The complexity of federal acquisition is increasing. Our ability as humans to mentally assimilate new laws, regulations, policies, and procedures into the existing body of knowledge in the acquisition field has already been surpassed." (9) Given this situation, procurement officials need a better way to make decisions given the complex environment in which they must perform. To accomplish this, managers must use a more structured approach to decision making. Enter the Analytic Hierarchy Process. The AHP is consists of three key principles:

1) Structuring Hierarchies. A large problem, such as a source selection decision, is broken down into its component parts.

2) Establishing Priorities. Decision-making factors are compared to each other to determine their relative impact.

3) Logical Consistency. Coherent relationships are established among the elements involved in making a decision. This is important for generating measurement scales. (10)

Expert Choice is a commercially available, personal computer-based Decision Support System which uses the AHP. This particular DSS has been used for a variety of procurement-related decisions, especially those involving "best value" source selections. Cook makes the following observations on Decision Support Systems based on the AHP:

> "Models ... can be applied with immediate results to virtually any complex decision situation. As a general rule, Expert Choice and other microcomputer-based decision support software is relatively inexpensive, requires little training to become proficient, and is available now." (11)

Expert Choice can accommodate a variety of source selection models. However, the software has the highest payoff for complex, large-scale source selections. There are many benefits of using a DSS for source selection. First, the DSS helps Government contract managers structure and weight evaluation criteria faster and more accurately than using a manual-based approach. This means procurement officials can more readily make decisions involving multiple criteria and alternative choices. The result is a faster and more accurate source selection decision as well as an overall reduction in PALT. Second, a DSS reduces the time required for human functional experts to support the Source Selection Evaluation Board (SSEB). This is an important consideration since the SSEB process can be a time-consuming and labor-intensive undertaking. Compared to using a DSS, a SSEB using manual-based evaluation methods means valuable time of engineers, program mangers, and contract specialists is unnecessarily used. Third, use of a DSS simplifies the briefing of the source selection decision process to the Source Selection Authority. Lastly, the use of a DSS helps ensure all proposals are fairly and objectively considered; this also can help the Government reduce protests since the source selection decision is more defensible.

It should also be noted a DSS can also be used to determine if a competitive procurement should be held in the first place. Cook used a DSS to determine whether the U.S. Air Force should "break out" the procurement of a major radar system (from the prime contract) on the F-15 fighter aircraft. Break out was considered due to past problems of late deliveries of the component by the vendor. The decision criteria used to determine whether breakout should occur were: 1) cost, 2) management visibility, 3) integration, 4) management effort, and 5) schedule. Using the AHP, these criteria (and their subcriteria) were incorporated into the DSS model. The result was the DSS recommended break out not occur, the Government agreed. (12)

WARRANTY ANALYSIS. Due to some well-publicized failures of weapons systems, Congress passed the Weapon System Warranty Act (WSWA) in 1984 as a means to improve the quality of major weapon systems purchased by the Department of Defense (DOD). Prior to the enactment of the WSWA, the predominately used DOD warranties were the Correction of Deficiency (COD) Clause and the Reliability Improvement Warranty (RIW), the former being the more prevalent. The COD clause focused mainly on materials and workmanship and was primarily component orientated.

Prior to the WSWA, weapon system performance, per se, was not warranted. Rather the standard COD clause was simply inserted into the contract. As a result, many DOD system program offices did not tailor warranties to their specific needs. This situation occurred since the guidelines for preparing and administering warranties were few and far between. Guidance for even component warranties was vague. There was also a lack of emphasis on performing warranty cost-benefit analyses (CBAs).

WSWA Requirements. The WSWA, 10 USC Section 2403 (Major weapon system: contractor guarantees), requires system-level warranties for all major Department of Defense weapon systems used directly by the Armed Forces for combat. As implemented in the DOD FAR Supplement, the WSWA also requires warranties for major subsystems. Spare, repair, or replenishment parts are not covered by the WSWA requirements.

The WSWA is significantly different from prior DOD warranty provisions. The major change is the specific requirement to warranty performance for weapon systems. The emphasis is also changed from component-level to system-level warranties. The WSWA imposes statutory, as opposed to regulatory requirements, on the prime contractor to provide three types of warranties for a weapon system, i.e., 1) freedom from defects in materials and workmanship; 2) conformance to essential performance requirements (EPRs); and 3) conformance to design and manufacturing requirements. As a result, the Government now minimizes its role as a self-insurer of their weapon systems. Consequently, the responsibility for remedying defects has shifted from the Government to the prime contractor. The WSWA means: 1) the DOD will not depend on implied versus explicit warranties and 2) specified EPRs must be used.

The buying implications of the WSWA are significant. Warranty decisions are now more complex. Previously, a clause was simply inserted into the contract. Now a contracting officer must conduct a structured and in-depth analysis to determine if the warranty is cost-effective and if so, how much coverage should be obtained.

Warranty Analysis Decision Support System. The Analytic Sciences Corporation (TASC) has developed a computer-based DSS to assist DOD procurement officials with warranty-related decisions. The DSS was originally developed for the Air Force Product Performance Agreement Center at Wright-Patterson AFB, Ohio. According to Contract Management magazine, the Warranty Analysis DSS has two major modules. They are described in more detail below:

> The heart of the DSS is the ANALYSIS subsystem, made up of the Warranty Selection Criteria Module (WSCM) and the Computational Analysis Module (CAM) of warranty choices.

The WSCM leads the user, employing a series of questions and prompts, through the maze of warranty choices. The outcome is a very small (one or two) set of potential warranty types, down-selected from all known types of warranties. The WSCM is typically used by program analysts to converge on the type of warranty that best fits their program.

The computational Analysis Module (CAM) complements the WSCM by providing a host of tools that can be used to analyze the WSCM "recommendations," or to conduct any warranty analysis. (13)

The DSS helps answer such questions as: "What kind of warranty is appropriate for an avionics upgrade system, to be produced in large quantities and operated for many hours?" (14) The DSS uses a multi-disciplinary blend of the following activities to solve the following types of warranty problems: EPR analysis; reliability analysis, reliability projections, risk analysis, warranty pricing, life-cycle cost analysis, cost-benefit analysis, and engineering studies. The Warranty Analysis DSS has been successfully used to solve warranty-related problems on more than two dozen projects. (15)

The Warranty Analysis DSS greatly simplifies the contracting officer's task. Consider that a major weapon system can have hundreds of potential (warrantable) EPRs. Also consider trying to match the right of warranty to the various EPRs. The task, without automated support, could be overwhelming to a buyer. However, the use of DSS allows for the consideration of many possible alternatives and results in a tremendous time savings over manual methods. The DSS also allows for tailoring of the warranty to achieve optimum results.

More recently, TASC has developed T-AWARE (TASC's Automated Warranty and Risk Evaluator), an advanced version of the DSS, for personal computer applications. T-AWARE adds powerful risk and cost-benefit analysis tools and graphics, while requiring only a fraction of the DSS inputs.

ACQUISITION PROCESSING EXPERT SYSTEM (APES). The Expert and Decision Support Systems discussed above are used for selected portions of the procurement process. This means only parts of the procurement process could be automated. The APES combines expert system technology with traditional computer applications to become an integrated, cradle-to-grave electronic contracting system. Examples of conventional functions performed are tracking of contracts and related correspondence, statistical reporting on contracting actions, and generation of contract forms. Some key portions of the expert and knowledge-based portions of the APES are:

1. Statement of Work (SOW) Writer. The APES contains a knowledge base of the formats and types of information required in various SOWs. The system helps the buyer(s) identify the correct SOW type, e.g., performance work statement, research and development, purchase description, and/or specifications. Once completed, APES checks the SOW and addresses any lists of standards or data item descriptions that should be included in the SOW.

2. Procurement Milestone Management. The APES, in addition to tracking purchase requests, is also able to determine if any steps have been omitted. This is an important consideration since acquisition planning can be a very complex task, and as a result, steps can inadvertently be omitted. APES provides a quick way to verify the accuracy and completeness of procurement planning dates.

The result is a system which assists a buyer through the entire contracting process, from requirements formulation to contract closeout. In addition to the above, the APES is able to gauge the knowledge level of a particular user. Thus the level of guidance provided by APES varies based on the skill level of the human

user, e.g., novices receive more guidance and support than a mid-level user would. The APES was developed by United Information Systems of Beltsville, Maryland and L.N.K. Corporation of Riverdale, Maryland. (16)

ACQUISITION SCHEDULING. The Weapon System Modification Schedule Evaluation Expert System (ModES) supports the U.S. Air Force with managing its modification programs. The personal computer-based system was developed by Intellogistics of Columbus, Ohio. The ModES helps high-level Air Force acquisition managers review modification schedules prior to their submission to Congress.

A modification program, especially for a major weapon system, can involve numerous inter-related and time-sensitive activities. While ModES does not design the modification schedule, it reviews the schedule for inconsistencies and then suggests a revised schedule, if required. Specifically, the system compares contract schedules with modification kit installation schedules. This is done by using past history current resource constraints, and projected schedules.

After evaluating the data, the ModES is able to determine: 1) if the schedule is complete, i.e., no missing activities such as a design review and 2) whether the program office will be able to accomplish the modification within their schedule. The ModES automatically highlights acquisition schedule disconnects. For example, the late purchase of a long-lead item, e.g., modification kit would be flagged for attention. Use of automation tools such as ModES offer contract managers significant insights into the critical factors involved with their acquisition schedules, helps them reduce costs, save time, and improve service. This is an important consideration given the need to keep track of many required procurement milestones for a large number of modification programs.

LOGISTICS EXPERT SYSTEM ADVISOR (LESA). The LESA is an Expert System that helps managers determine the feasibility of using an expert system for a particular logistics application, e.g., purchasing. LESA was developed by Intellogistics. The system asks a manager questions about the type of purchasing problem to be solved. Based on the manager's answers, LESA provides a rough order of magnitude of estimate on the effort required to develop an Expert System to solve the particular problem. The estimate tells the user approximately how much it will cost to develop the proposed system and how long it will take; return on investment is also calculated. LESA also tells the user, in general terms, about the type of hardware and software that will be required, e.g., a rule-based shell. (17)

LOGISTICS PLANNING AND REQUIREMENTS SIMPLIFICATION (LOGPARS). Government Computer News notes the personal computer-based LOGPARS performs a variety of procurement-related functions. The system was developed by the Army Materiel Command's Material Readiness Support Activity (MRSA) in Lexington, Ky and has been applied to 334 acquisition programs. LOGPARS offers expert advice in five subject areas:

1. The Strategy Adviser module asks the user a series of questions on program strategy, including phases and types of acquisition. Then it recommends tasks and reports for each program element.

2. The Schedule Adviser module automatically tailors a milestone schedule based on the program strategy. It shows dependencies and offers gaming, slipping, squeezing and flagging options to assess the impact of changes.

3. The Plan Adviser module leads the user through preparation of a baseline plan, complete with policy guidance and expert advice.

4. The Statement of Work Adviser tailors contractual requirements and itemizes descriptions and tasks.

5. The Warranty Adviser asks a series of questions to determine legal requirements and helps word a baseline warranty clause to go in the request for proposals.

Each LOGPARS module maintains an audit trail of questions and recommendations. MRSA is developing new modules to advise on costs, transportability and other issues. (18)

EXPERT SYSTEM IMPLEMENTATION

Implementation Problems. This section begins by discussing generic and procurement-specific problems associated with Expert System implementation. The best overall strategy to ensure success is to use a structured approach to Expert System design and development. The need for a structured approach increases as the system becomes more complex. Use a standardized approach, if possible.

Contract managers interested in using Expert System technology should consider some basic rules. To succeed a system must be properly designed. This requires a disciplined, systemic approach; the alternative is a piecemeal approach which can cause serious long-term problems with user support and system accuracy. There are no shortcuts in this regard. AI Expert offers an overall lesson learned regarding the development of a Knowledge-Based System (KBS):

> ... a more basic problem lies in the difficulty of analyzing and organizing knowledge efficiently, with the result that many KBSs get started but never finished. A certain paradox exists: on one hand, building a KBS initially appears so easy that time and resources are routinely underestimated; on the other hand, preparing the knowledge for a useful KBS keeps mushrooming and frequently falls prey to the so called combinatorial explosion. (19) In fact, one industry expert estimates only 10 percent of medium-to-large sized Expert Systems are successful. (20)

Other generic advice is to obtain the assistance of outside experts, when required. This would normally occur at such critical phases as: system specification preparation; prototype development; and independent verification and validation. Prototyping is highly recommended as an effective risk management technique. Developers should use an Expert System language that is easy to understand and support. Lastly, it is critical to determine the needs of the functional Expert System user.

There are a variety of inter-related procurement-specific implementation problems. Based on personal experiences as contract manager in Government and Industry, the author believes the following types of procurement-unique issues will need to be addressed with as part of the effective implementation of Expert Systems in Government procurement field.

- The size of the knowledge base is immense. Consider, the basic Federal Acquisition Regulation has approximately 1,000 pages. However, the FAR is usually accompanied by supplements from each Federal agency as well as additional supplements by each agency's major operating departments. For example, in the DOD, the FAR is supplemented by a voluminous DFARS. The DFARS is, in turn, supplemented by each military service's version of the FAR, e.g., Air Force FAR Supplement. This leads to a very complicated regulatory environment which poses significant demands on the developers of Expert Systems.

- The FAR and its supplements are frequently changed. This is an important consideration for an Expert Systems since even minor changes in knowledge rules can have a big impact in system accuracy and performance. It can also be very costly to make frequent changes to the knowledge base.

- The FAR and its supplements are subject to varying interpretations. This means it may be difficult to get a consensus of what answers the Expert System should provide. The situation is further complicated since the same contracting process can vary from

location-to-location. For example, spare parts pricing for major weapon systems can vary depending on such factors as accounting method used and type of commodity purchased.

- There is no consistent set of professional standards for Government procurement officials. For example, there is currently is no formal requirement for a baccalaureate degree. In fact, only half the Government procurement workforce has a bachelor's degree or better. Many of those persons with degrees are not in procurement-related fields such as purchasing, law, or accounting. This means there is a wide variance in the business-related educational level of potential Expert System users in the GS-1102 field. Based on the author's personal observations, experience is not a good guide for gauging knowledge and/or proficiency levels. The lack of standards means the task of developing an Expert System is greatly complicated since the designers do not have a good benchmark for gauging an "average" users knowledge.

- Functional area experts in contract management often come to different conclusions, even when they use the same sets of rules. For example, Part 16 of the FAR discusses the types of considerations for using various types of contracts. One contracting officer (CO) may believe a cost-plus-fixed-fee type of contract is best for a systems engineering contract. Another CO may believe a time-and-materials contract best, while yet another CO would use a cost-plus-award fee. Other areas where contracting experts may disagree are on the bid/no bid decision and the measuring of purchasing performance.This means there are many personal biases and frames and references which need to be accounted for when developing an Expert System for functional users.

Support Requirements. A system is only as good as its support. This is an especially important consideration for Expert Systems. Support problems in the procurement field should be expected due to: 1) the need to keep the databases current to ensure compliance with procurement laws and regulations, this can be considerable if frequent changes occur; 2) difficultly with maintaining non-standardized Expert Systems on various shells that may not interface with each other; 3) a shortage of human experts to maintain the systems; and 4) varying user needs based on specific contracting missions.

It is important to realize each new Expert System added requires additional overhead with respect to a user support. Unsupported Expert Systems will most likely fail to be used.

Large, Centralized, Systems. Use of a mainframe to host an Expert System can become unwieldy, especially since a centralized system requires uniformity where it may not be possible. Flexibility is required, especially when field offices are geographically separated and deal with different clients, accounting systems, commodities, etc. As a practical matter, it is difficult, if not impossible, to design a one-size-fits-all type of Expert System. Hence, the recommendation to use a personal computer-based approach. Use of PC offers the following benefits over a mainframe: reduced overhead; increased flexibility; and lower startup costs.

SUMMARY

Applications for Expert and Decision Support Systems in the procurement field will proliferate. This will be an evolutionary process as contract managers become educated on the capabilities and benefits of Expert Systems. Early adopters, especially in the for-profit professional services type business, will be rewarded with the following types of benefits:

- They will be more competitive;
- Have lower overhead;
- Be more productive with less people;
- Realize improved decision-making accuracy; and
- Improve their profits.

Expert Systems will be only one part of an increasing automated contracting office in the 1990s. In the long-term, interconnectivity between Expert Systems will increase. This will significantly improve their capabilities by allowing them to considering more integrated solutions to procurement issues. However, in the near-term, contract managers will have to be satisfied with expert system that solve specific problems in narrow areas of specialization.

Expert System technology is changing rapidly. This means it is essential to keep up with current developments to determine optimum application and implementation strategies. Given the trend toward rapid and ever-increasing capabilities, users should expect to see more Expert Systems based on personal computers instead of mainframes. This will help promote their wide-spread use.

CONCLUSIONS

Expert Systems are here to stay. The use of Expert Systems will increase in the years ahead given the ever-growing complexity of the legal, technical, financial, and regulatory environment in the Government contracting arena. Some specific reasons for the growing need for this technology are: 1) continued changes to and expansion of the FAR system; 2) increasing scope, complexity and dollar value of procurements, i.e., consolidating requirements; 3) difficulty with attracting and retaining human experts; and 4) the on-going need to provide initial and upgrade training; and the 5) the continued emphasis to improve purchasing performance, especially in making "best value" buying decisions. The use of Expert and Decision Support Systems will improve the efficiency and effectiveness of the contracting function as well as improve the service it provides to various customers, e.g., program managers and technical officers.

The use of Expert Systems in the procurement field will not be without incident. Some of the problems to be overcome are:

Regulatory Inertia. It may take some time before the FAR and its supplements are revised to reflect the use of Expert and Decision Support Systems. This will gradually change as this technology becomes more commonplace, and hence accepted.

Cyberphobia (fear of computers). Many contract managers have only limited computer skills, e.g., spreadsheets and word processors. The use of Expert Systems represents a significant challenge to learn about a new technology and how to effectively apply it.

Resistance to Change. This is closely related to cyberphobia. Some contract managers may be anxious about introducing Expert System technology into their organizations since it may represent a threat to their status.

Decision Support/Expert Systems are designed to improve the quality of decision-making as well as to improve effectiveness, productivity, and service levels. The purpose of this emerging technology will be to assist - not replace - contract managers.

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OPTICAL DISK SYSTEMS FOR THE ACQUISITION OFFICE OF THE FUTURE

by

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ABSTRACT

Imagine the acquisition office of the future. Electronic Document Interchange has become a fact; automated electronic acquisition is a reality. But you still find yourself buried in a flood of supporting documentation on paper. The electronic office has not reduced paper in our offices; instead it has made it easier to produce paper documents.

In today's acquisition office, documents prepared in support of the automated acquisition process are managed by storing their data files in electronic file folders. Unfortunately, the supporting paper documentation is still being stored in and retrieved from file cabinets. We believe that the acquisition office of the future will, unhappily, still be immersed in a deluge of paper.

Innovative optical disk systems can help us better manage documentation and information. Optical disks use laser beams to safely store huge amounts of information, e.g., 6.55MB or 128,000 pages on one 12-inch Sony write once optical disk.

Optical disk image management systems store and retrieve images of the paper acquisition documents and link them to the electronic file folders containing acquisition files. Exact replicas (images) of all acquisition documents, including those received from the outside, can be retrieved and displayed in seconds. And they cannot be lost or misfiled.

Implementation of these systems is not a promise of the future. Today, optical disk document management systems are being integrated with electronic documents on existing computer systems in a wide range of applications. This presentation describes how they may be integrated with contracts automation and acquisition information management systems.

INTRODUCTION

In the acquisition office of the future, electronic document interchange (EDI) has arrived; true and full electronic acquisition has become a reality. Work is performed electronically at the personal workstation. Everything is great, except we are still buried in an ocean of paper.

In the United States today, 95 percent of our information resides on paper (1). Toffler (2) states "In one year the United States turns out 1.3 trillion documents -- sufficient, according to some calculations, to 'wallpaper' the Grand Canyon 107 times. All but 5 percent of this is still stored on paper. Advanced information technologies, including document scanning, promise to compress at least some of this."

The electronic office has, contrary to early prophets, not effected the paperless office; on the contrary, it has made the production of paper even more efficient. Weber (3) reports that each day, U.S. companies produce 600 million pages of computer printout, 234 million photocopies, 76 million letters, and 21 million other paper documents. Every

day, 45 sheets of paper are added to the files for each office worker. Demand for paper as a storage medium is growing at from 5% to 7% a year.

The purpose of this paper is to review the status of acquisition automation today, present an overview of optical disk technology and its potential for paperless acquisition automation, and to develop a plan for image management strategic initiatives.

ACQUISITION AUTOMATION

Many of the automation systems being suggested for contract management for the 1990's are largely directed toward automating the paper production process. There is a high probability that the acquisition office of the future will still be immersed in a flood of supporting paper documentation.

Murphy (4) described several systems designed to automate the production of requests for proposals, including word processing libraries, checklists for maintaining available clauses and provisions, and knowledge-based artificial intelligence systems. Murphy concludes that automated contracting reduces the lead time for the generation and approval of solicitation and the contract document.

Bibin (6) showed how a corporation can gain a competitive advantage with specially designed teams of personnel employing personal computers to automate the proposal preparation process. Advantages gained include: identifying information and resource needs, concentrating on a quality product, more efficient use of information resources, and more efficient use of time. Bibin states "The bottom line is a competitive edge to bidders who best integrate the use of these evolving (computer) tools."

Drake (7) addressed the application of information systems technology to procurement automation. Technologies he included were electronic workstations, networks, optical disk storage, E-mail, electronic document interchange (EDI), expert systems, and electronic bulletin boards. According to Drake, local and wide area networks and open systems interfaces provide the necessary integration, and the optical disk and EDI technologies provide for a "paperless" procurement automation process.

Drake states that electronic contracting will provide paperless processing, data and information sharing, and quality decisions. These, in turn, provide for better buys. Drake presented two examples of paperless electronic contracting: the Defense Logistics Agency's Paperless Order Processing System (POPS), and the SAMMS Procurement by Electronic Data Interchange (SPEDE). In some of the other examples Drake presented, the automated systems produce paper award documents.

We believe that the acquisition office of tomorrow will still function with a heavy reliance on paper documentation irrespective of automation efforts (perhaps even because of automation). What is needed is a means to automate acquisition information including: 1) data and files created by the acquisition process, 2) image information created by or in support of the acquisition process, and 3) supporting base documentation. Optical disk image management systems, coupled with other facets of acquisition

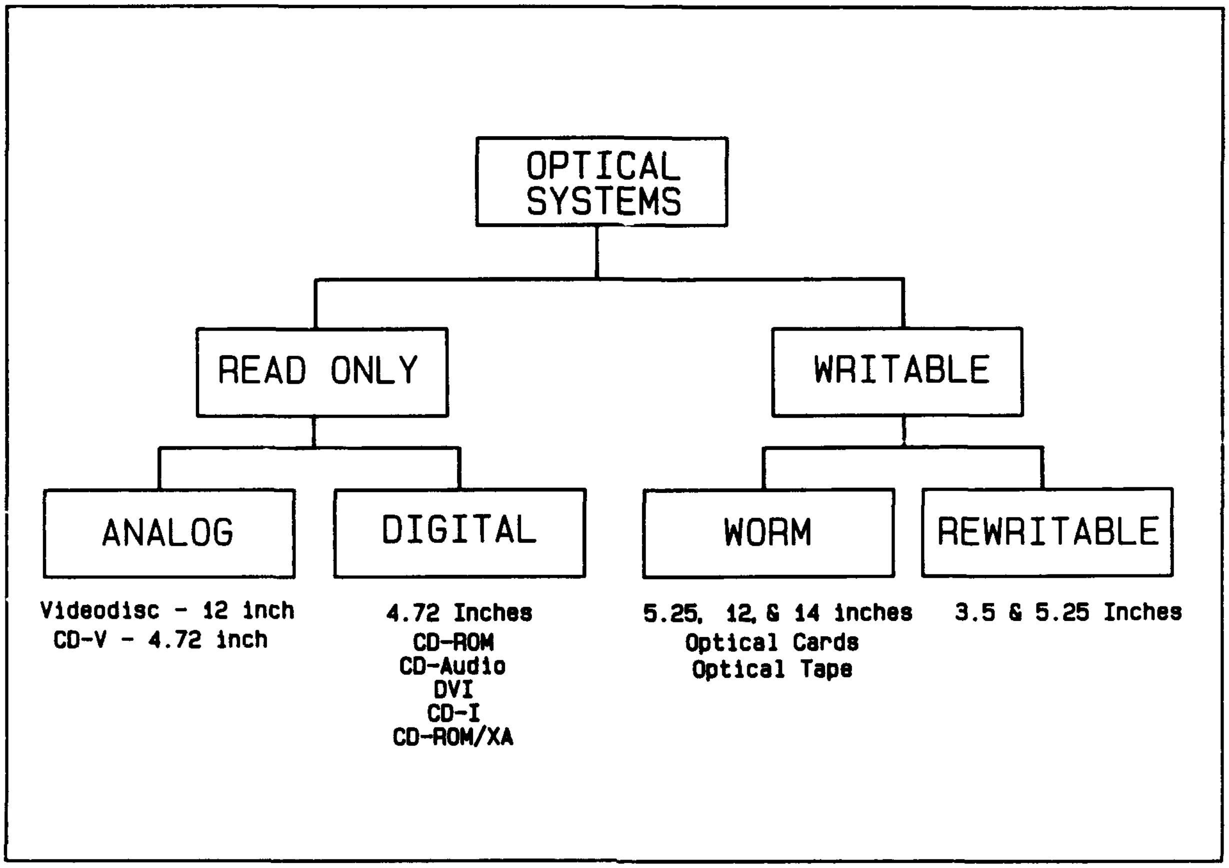

Figure 1 Types or categories of optical disk recording systems

automation, offer considerable promise in these areas.

OPTICAL DISK SYSTEMS

There are two primary categories of optical memory systems: 1) prerecorded (read only) and 2) user recordable or writable (see Figure 1). Prerecorded optical disks consist of compact disc read only memory (CD-ROM) and videodiscs; writable include write-once read-many (WORM) and rewritable optical disks. Videodiscs are used to record video and audio information in analog form and will not be included in this dissertation.

Optical disks use microscopic laser beams to safely store very large amounts of information (see Figure 2). One Sony 12" dual density WORM optical disk, for example, can hold 6.55MB of data, which equates to about 128,000 pages (10 filing cabinets) of acquisition documentation in image form.

Document Storage on Optical Disk

WORM optical systems are best suited for electronic image management applications such as archival and transaction storage of documents, files and other large information bases in image or raster bit-mapped form. WORM optical disk systems favorably compete with paper and microform for document storage, and enhance information retrieval and transaction processing.

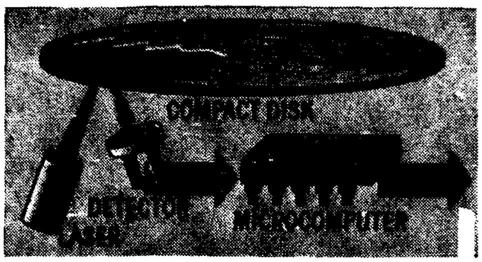

Figure 2 Schematic for recording information on an optical disk

WORM document storage and retrieval systems record information in image form, and generally can include all forms of information -- typed, forms, graphics, handwritten materials, photographs, audio, and video. An optical disk document system usually consists of a scanner to convert the image on paper to an electronic image, a laser printer, WORM disk(s) for storage, raster image processing firmware for image compression, software for indexing and retrieval and, of course, a computer to manage the entire process. An example of a WORM optical disk document image processing system is the LaserData system shown in Figure 3.

Image storage does not capture the document's contents in ASCII form but instead stores the contents of the page as a large number of picture elements (pixels) that make up an "electronic picture" of an image (see Figure 4). Images can be recorded, stored, transmitted, and printed, but they cannot be directly included in a word processing file except as a graphic image (8).

Documents are scanned at a density of 200 or more pixels per inch (ppi) in both directions. Simple arithmetic shows that an 8.5 x 11 inch page scanned at 200 ppi would result in 3,740,000 pixels (or bits) per page. By employing internationally standard compression algorithms, this is reduced to about 30,000 to 50,000 bytes, which is reasonable for optical disk document management systems.

An optical disk drive may be used as a single or stand-alone unit, or up to 8 drives may be connected. WORM systems frequently employ a jukebox (sometimes called a library unit or autochanger), which is a robotic mechanism that transports optical disks from a storage rack to the optical disk drive. Optical disk jukeboxes are available with capacities ranging from 16 to several hundreds of optical disks (see Figure 5); they are available for 5.25-, 12- and 14-inch media.

There are many benefits from using optical disk document storage and retrieval systems. These include higher productivity and lower costs; improved customer service; space savings; reduced staff; jobs enhancement; improved work environment; elimination of lost and misfiled documents; simultaneous access to documents; rapid response to inquiries; text, data, and image on a single system; and integration with existing computer system.

Benefits resulting from implementing optical disk can be quite striking. For example, one year after implementing an optical disk system at Investors Group of Canada (9), staff was reduced 43 percent from 46 to 26 and the 20 persons were assigned to other departments at IGC. IGC staff can simultaneously access documents and lost, misfiled, and out of

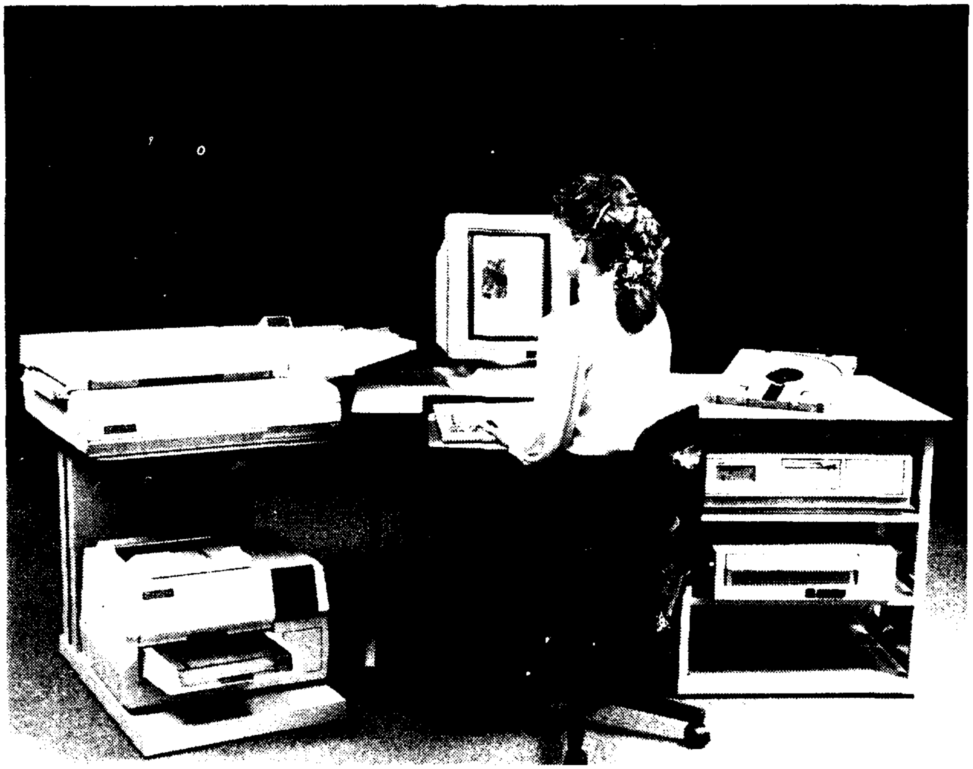

Figure 3 LaserData optical disk document image management system

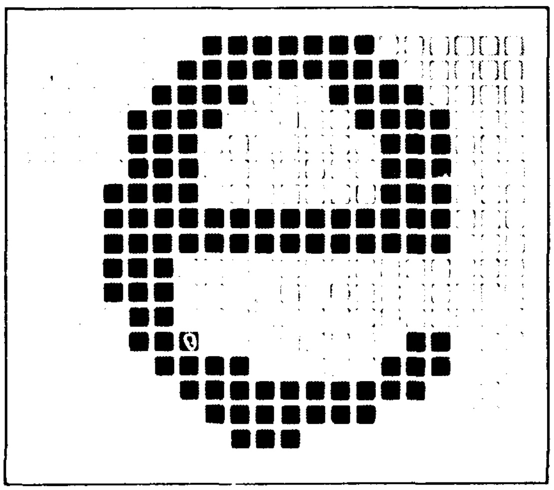

Figure 4 Illustration of how a letter is captured in image or bit mapped form

file documents were eliminated. Storage space was reduced and copying was likewise reduced extensively.

Fast access to account information at IGC means faster response to customer inquiries, a hallmark of good client relations. "Our Client Relations and Shareholders Administration departments can respond to telephone inquiries on the spot instead of having to call the client back once appropriate documentation has been consulted."

WORM and Computer Data Archival

The WORM disk's slower access times and the inability of these disks to erase and rewrite data have made WORM disks

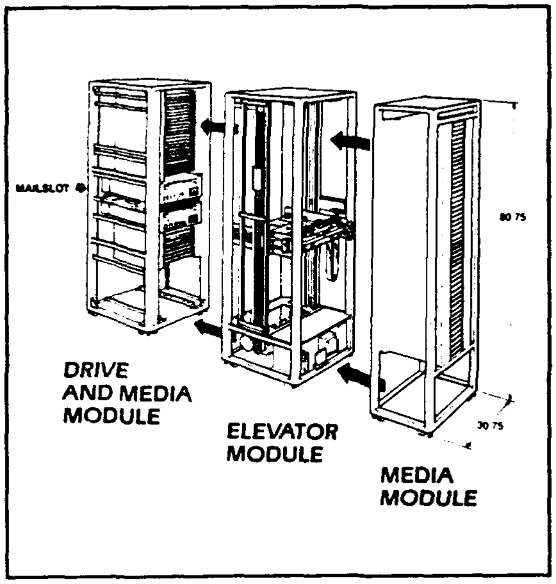

Figure 5 Optical disk jukebox

less attractive than magnetic storage for computer data storage. But WORM optical disks are being used very successfully to replace magnetic tape for computer data archival and for computer output microfilm (COM) applications (called COLD for Computer Output Laser Disk).

One 12-inch dual-sided optical disk stores the equivalent of 40 magnetic tapes. Since optical disks provide random access, they offer quick entry to archival data. The savings from optical disk data archival results from lower computer operator costs over comparable magnetic tape operations. For example, a major oil company realized sufficient savings from the implementation of an optical disk system for arching its several millions of magnetic tapes of seismic data to pay for the $3 million optical disk system in less than 6 months (10)!

Rewritable Optical Disk

Rewritable (or erasable) optical disks became commercially available in 1988. These magneto-optical rewritable optical disks are being used in document storage and retrieval systems. But some records managers prefer to use WORM optical disks in order to have an unchangeable audit trail of a document's life cycle (in many cases this is mandated for legal or policy reasons). Rewritable optical disks are being used frequently in data processing applications.

CD-ROM

CD-ROM (compact disc read only memory) is a 4.72-inch optical disk on which 300,000 pages of typed text, 1,600 floppy diskettes, or 10 reels of computer magnetic tape can be recorded. A CD-ROM is designed to be integrated with a personal computer by adding the CD-ROM player and a board (see Figure 6). Player costs are relatively low (under $400).

As the term ROM (read-only memory) implies, a CD-ROM system cannot write new information to a CD-ROM disc at the user's location (11). Instead, a CD-ROM disc is manufactured in a specially designed clean room production facility by an injection molding process. Because of this production process, some minimum number of copies (say 30 or more) should be made. It takes about 6 seconds to "write" 600 MB of information to a CD-ROM; production costs are about $2 to $5 per disc.

CD-ROM is an ideal optical medium for distributing information in a uniform format to a large number of sites at low cost. An excellent application of CD-

Figure 6 CD-ROM drive

ROM for disseminating procurement related information is FED LOG, the Federal Supply Catalog on CD-ROM. The 2-disc FED LOG CD-ROM contains descriptive information on more than 12 million individual parts. The supply catalog is coupled to an index and a retrieval software so that information can be retrieved in seconds or minutes instead of hours or days required by the microfiche version (12).

Because they have very large data storage capacity, writable optical disks sometimes are considered for disseminating information. But writable optical disks, either WORM or rewritable, must be written serially a byte at a time until the entire contents of the source disk are copied to the duplicate disk. This can take many hours or days depending on the data storage and transfer rates of the optical disk drives and the processing speed of the computer. Hence, writable optical disks are not viable contenders for information dissemination. Since CD-ROM discs are injection molded, they are much more appropriate for information distribution. It is important to note that the 4.72-inch CD-ROM is totally distinct from its 5.25-inch WORM "compact disk" cousin.

OPTICAL DISK FOR ACQUISITION AUTOMATION

In many acquisition offices, documents prepared in support of the acquisition

process are managed by storing their data files in electronic file folders, perhaps the way Apple Macintosh and Xerox use icons to signify the familiar physical file folders. These icon-like file folders hold your electronic files but lamentably the mounds of supporting paper documents must still be physically placed in space-consuming file cabinets and retrieved manually.

But suppose that your workstation could, in addition to all its current functions, also find and display electronic images of hard copy acquisition documents in this same icon-like file folder. Exact replicas of all acquisition documents, even those received from the outside, could be located and displayed in seconds for you to view and use without ever leaving your workstation. And since these documents are never removed from the electronic file, they cannot be lost or misfiled.

Implementation of these systems is not a promise of the future. Today, optical disk document management systems are being integrated with electronic documents on existing computer systems in a wide range of applications.

Flick (13) described an optical disk based image management Integrated Contract Imaging System (ICIS) being developed at the United States Air Force Systems Command. The system is designed to provide: a) a paperless contract file, b) on-line conformed contracts, c) an integrated relational database and imaging system, d) an expert system for buyers and contracting officers, and e) a dedicated link to the contractor's electronic system.

The ICIS has an optical disk electronic file cabinet and contains contract writing; correspondence routing, tracking and suspense; and optical character recognition and full-text retrieval modules. The ICIS provides random access to files, extensive cross reference indexes, association of contracts and modifications, multi-user images, and significant space reduction.

The goal of the Air Force Systems Command is "To develop a distributed image and information system that facilitates procurement excellence, endures manpower shortages, and changes in DoD procurement into the 21st century."

Goldsmith (14) also reported on an automated acquisition system that incorporates linkages to DSREDS (Digital Storage and Retrieval and Engineering Data Systems), an optical disk system for managing engineering drawings and change orders for procurement items. This system is designed to maintain quality technical data, provide accurate and timely responses, reduce the staffing requirement for each action, be cost effective, and increase the satisfaction of both industry and government customers.

Murphy (15) reported that paperless contracting is now possible because of several emerging technologies including optical disk. However, progress in the optical storage area has been hampered by the availability of only read-only media (pre-recorded and CD-ROM) and not writable media. According to Murphy, new WORM products overcome this limitation because they allow data to be written locally, provide an unerasable "audit trail," and have high data storage capacities. Murphy viewed WORM optical media as having great potential for storing and backing up large contracting databases but did not indicate whether optical disk based image processing would complement paperless contracting.

We are aware of two acquisition automation related applications using or planning to use optical disk document image processing systems. These include an invoice processing and management system (16) and a property management and inventory control system (17).

CONCLUSIONS

The contracts automation community is at the threshold of its efforts to integrate optical disk and image processing technologies into the contracts automation process. In addition to a broader general understanding of optical disk information management systems, the acquisition automation community could benefit from a better understanding of the appropriate applications of each of the members of the optical storage family. WORM and rewritable optical disk and CD-ROM can, in our view, play a major role in acquisition automation.

WORM optical disk is appropriate for two facets of acquisition automation: a) the conversion of information presently on paper to electronic image form for display and management on computer workstations, and b) the archival and working storage of large structured and free-form contracts automation databases.

Rewritable (erasable) optical disk may be used with document image processing systems but we think rewritable optical is most suited to applications involving dynamic and backup storage of large structured and free-form contracts automation databases.

CD-ROM has a distinct role to play in contracts automation. CD-ROM information bases such as FED LOG (or similar types of commercial products) are very appropriate. The Federal Acquisition Regulation (FAR) and many of its supplements are now available on CD-ROM. Vendors will provide commercial CD-ROMs with acquisition automation information if there is a demand.

CD-ROM's utility in acquisition automation will be restricted only by the availability of appropriate information bases in the CD-ROM format and by the imagination of the acquisition community. Why not, for example, issue RFPs in electronic form on CD-ROM or deliver acquisition automation software on CD-ROM? Information base dissemination is the forte of CD-ROM.

RECOMMENDATIONS

Organizations can increase their effectiveness by orders of magnitude through the strategic implementation of imaging technologies. The changes catalyzed by imaging technology enable an increased ability to provide superior services, an increased ability to process and manage information and knowledge, and an increased ability to produce quality output with fewer resources.

Developing organizational leadership in imaging applications is difficult because imaging involves widely divergent knowledge and skills. MIS departments may not adequately understand end user, records manager, and organizational requirements and expectations. End users may not appreciate the technical realities of an organization-wide information and image processing system. Possibly no one inside the organization will fully understand systems and processes redesign.

Imaging planning needs to incorporate business design, systems architecture design and human resources and organizational design, all under an umbrella of corporate strategic planning.

Winning with imaging requires aggressive action in six major areas:

1. Awareness and Values: Develop a keen awareness on multiple organizational levels of what imaging technology is, why it is important, and what the organization must do to reap its benefits.

2. Systems and Processes Redesign: Order of magnitude benefits can be realized from an aggressive and managed program of systems and processes redesign. More significant benefits accrue from major process redesign rather than from document storage alone.

3. Applications: Target high opportunity image processing applications; pursue "Phase One" of a high opportunity image application rather than initiate a pilot demonstration project.

4. Organizations and People: The human side of imaging technology must be managed. Imaging lets the organization leverage human endeavor, providing the performance monitoring information necessary to employ human resources wisely.

5. Impact on Systems Architecture: Images have a 1,000 to 1 impact on existing computer and operational systems. One image file cabinet (jukebox) can hold the equivalent of 1,000 paper file cabinets; one CD-ROM stores more than 1,000 floppy disks; an image page takes about 1,000 times longer to communicate on a network than a text page. Hence you need to establish long-range systems architecture planning for the design, development, and implementation of imaging technology.

6. Imaging Strategy and Funding: Create a pathway that outlines the steps for getting started, building credibility, obtaining funds, linking with other acquisition automation modules, integrating imaging with other information resources, and harvesting the benefits.

Imaging technology is one of the most important technologies of the 1990s. The question is not whether you will be using imaging technology but rather when, where, and how effectively will you use it to help realize your management objectives.

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(5) Presentation at "Exploring New Technologies for the 90's," Electronic Contract Management Conference, Washington, DC, 1990.

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(11) Present CD-ROM standards do not provide for writing data on a CD-ROM. However, ISO, the International Standards Organization, is revising its ISO 9660 CD-ROM Standard to provide for an appendable CD-ROM format. Named CD-WO for compact disc write once, this standard will extend the range of information and image management applications for which CD-ROM is appropriate.

(12) Thiel, Thomas J. and Edward J. Oakes, "The Navy's Paperless Ship Project: A Shipboard Integrated Write-Once Optical Disk CD-ROM System," in Judith Paris Roth, Ed., Case Studies of Optical Storage Applications, 1990, Meckler Publishing, Westport, CT, Chapter 5, pp. 53-64, ISBN 0-88736-535-3.

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(14) Goldsmith, Leonard S., "Automated Acquisition Systems: Electronic Requisition and Purchasing -- Managing the Black Hole," See (5).

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BUDGET and COSTS

DEFENSE BUDGET INSTABILITY: A COSTLY MALPRACTICE

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ABSTRACT

Budget instability in defense during the past 20 years is costly and unnecessary; costly because stable funding would provide more forces; unnecessary because most loss can be avoided if planners know what next year's top-line budget will be.

Planners then must plan rationally by funding ownership (operations, maintenance, manpower, and support) before financing new acquisitions. More simply, feed and cloth the family before buying a new car.

INTRODUCTION

The Costs

During the past 20 years the Navy received about $1.5 trillion measured in 1988 terms. Annual budgets grew erratically -- declining 5 percent, growing 10 percent, declining 6 percent, etc. That's unstable funding.

If budgets instead had grown at a steady 1.5 percent per year, the same $1.5 trillion would have yielded 15 percent more forces. The Navy could plan on 17 carrier battle groups in the 1990s instead of 15.

Budget instability has two components. One is the absolute change, from year-to- year, in the budget level; the other is uncertainty of those changes. If budgets are erratic, but known, effects of unstable funding are less severe.

If the Navy knew its top-line funding a year in advance, the loss in force levels would be about 5 percent instead of 15.

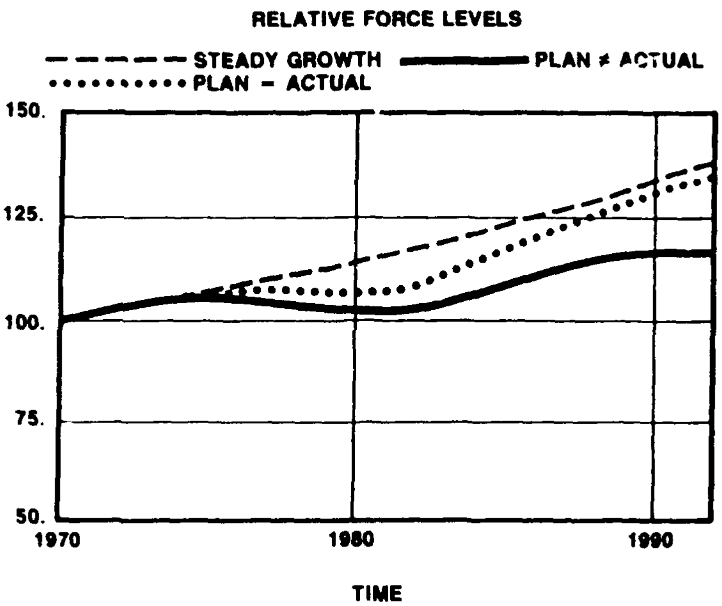
Figure 1 shows perspective. The top line shows force levels if budgets grew steadily. The second line shows effects of erratic funding, but with planned budgets equalling actual budgets. The bottom line shows what happens when planned budgets are estimated, and then changed to match actual funding.

Analogous results apply to the other Services, though growth patterns differ. Let's look at their dynamics in general terms.

Acquisition Versus Ownership

When budgets suddenly change, force levels do not necessarily change immediately. Weapon systems stay active until they age enough to be inactivated. Therefore weapon systems for

FIGURE 1. FORCE LEVELS AND BUDGET STABILITY



"ownership" funds (operating, maintenance, manpower, and support) also change slowly. This implies that unless ownership accounts are under-funded, or inactivations are forced prematurely, budget changes must be absorbed by acquisition accounts.

For a crude perspective, if acquisition is one-half the total budget, then a 5 percent change in overall funding translates into a 10 percent change in acquisition. If acquisition is one-third of the budget, then a 5 percent budget reduction means a 15 percent reduction.

Acquisition budgets as "swing" accounts are confirmed by historical data. Figure 2 compares fractional changes in actual defense budgets with changes to procurement accounts. When budgets change, the proportional changes to procurement are two or three times greater.

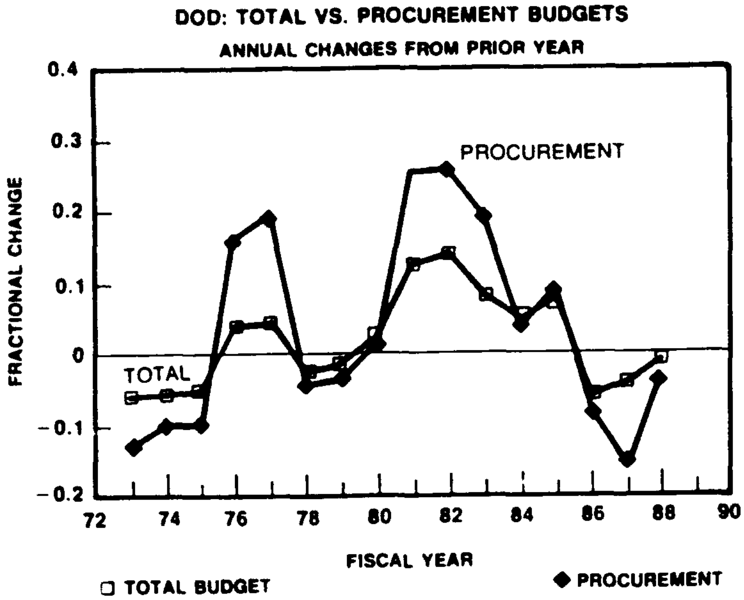
These dramatic budget changes affect unit costs and quantities produced.

Cost/Quantity Dynamics

There is a necessary relationship between unit costs and quantities procured, and the budget changes made. This relationship is complex but can be derived from logic and confirmed by historical data.

Data show there is a different relationship between these factors for **assumed** budget changes, as when plans are made,

FIGURE 2. PROCUREMENT SENSITIVITY



and for **unexpected** budget changes, as when plans are revised. This is a key difference.

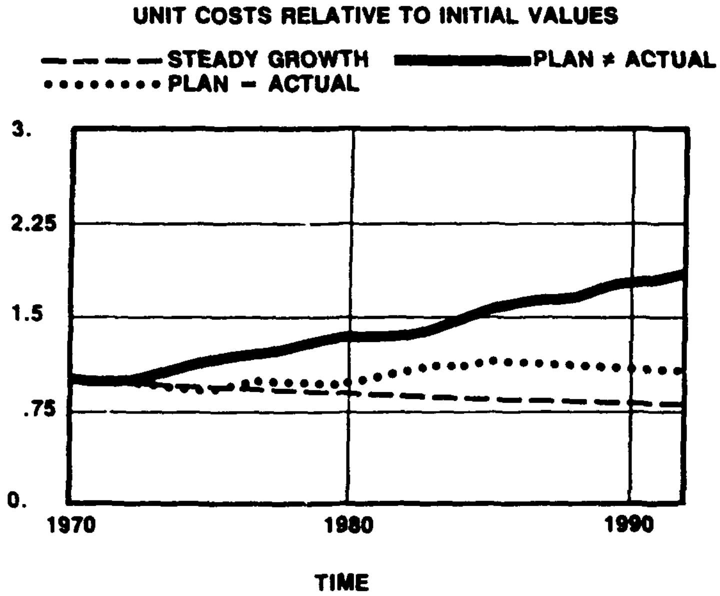
Suppose a Service plans on a 5 percent budget increase, and a year later that increase is negated. There is a net zero percent change, but unit costs will rise about ten percent due to the planned change. There would be no increase if the zero percent change was planned.

The difference is embedded in the "elasticity" of unit cost with respect to quantities: how much unit costs change, proportionately, when quantities change. Historical data from 1976 through 1987 show this elasticity is about twice as large when changes are **unplanned** instead of planned.[1]

One likely logic behind these differing elasticities is that changes to plan occur later in the planning cycle, causing inefficient adjustments to production plans. Changing the architect's drawings late in the process is costly even if construction of the house hasn't begun. Perhaps the builder has less reason to bid low if he knows the buyer needs the house soon. Whatever the cause, the two elasticies result from actual historical data.

This means that it is costly to change plans. Furthermore, over time, annual unit-cost inefficiencies are embedded in cost-estimating relationships used to derive future costs. Estimates for future systems become inflated. Figure 3 shows typical unit cost trends with steady growth (bottom-line), erratic growth with planned

FIGURE 3. UNIT COSTS AND BUDGET STABILITY



budgets equalling actuals (middle-line), and erratic growth with planned budgets not equalling actuals (top-line). Growth in unit costs with uncertain, erratic budgets is about 4 percent per year greater than with stable funding. More than two-thirds of the relative unit cost rise is due to uncertainty; that is, planned funding not equalling actual funding.

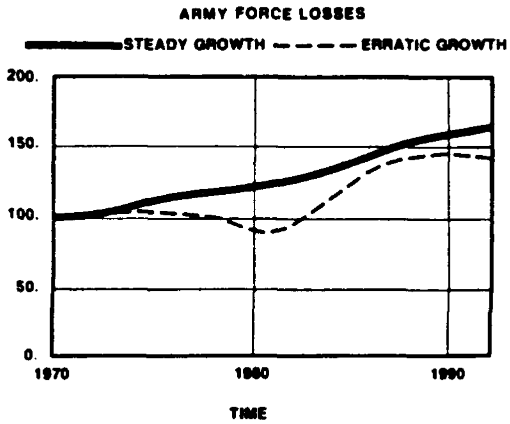
Interservice Dynamics

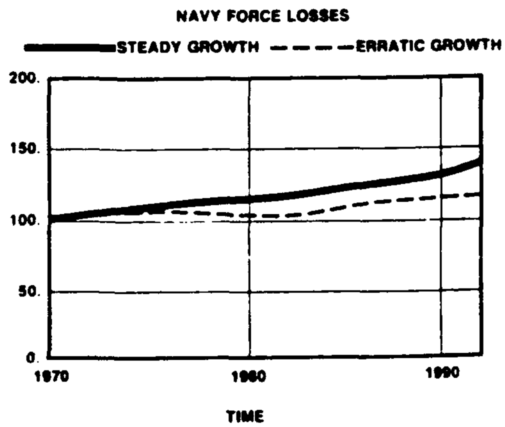
Consider the graphs in Figure 4 showing force levels relative to their initial levels for the Army, Navy and Air Force. Each graph compares force levels that would occur with stable funding and unstable funding. Total funds obligated by each Service (approximately) equal those actually obligated during the past 20 years.

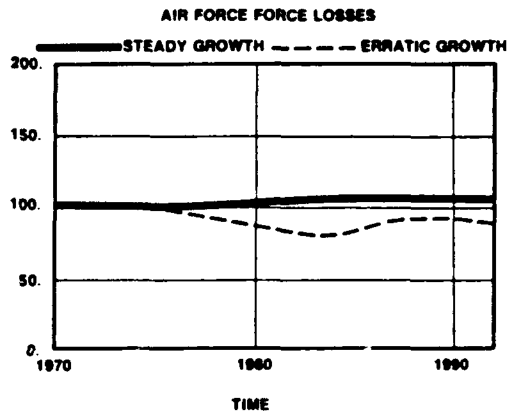
The curves do not provide absolute values for force levels, but yield insight into the affects of instability. Absolute values are affected by things like individual valuation of specific units, and inclusion or exclusion of system categories like ballistic missiles. Nonetheless, relative levels of the three Services shown are fairly consistent with results of a congressional report, which found Army assets growing about twice as fast as the Navy, and the Navy about twice as fast as the Air Force, during the 1970s and 1980s.[2]

Air Force assets in Figure 4 are relatively suppressed, over time, because the model includes missiles in a "support" category, instead of as "force levels." Much 1980 Air Force growth was in the missile procurement account.

FIGURE 4. DYNAMIC DIFFERENCES BETWEEN SERVICES







The average growth in real spending for the Air Force was lower than for the other Services. Total Navy obligations during 1970-90 equate to a +1.5 real percent growth per year; the Army to +.15 percent; and the Air Force, no growth.

Two main observations can be made from Figure 4. Army dynamics, the variance between steady and erratic growth, are more extreme than those of the Air Force; the Navy is the most stable. Budget changes to the Army cause fairly extreme changes to force levels in the near-term. Thus, Army assets suffered dramatically in the 1970s and in the late 1980s when money was scarce.

The second observation is that the Army is affected quickly but it recovers rapidly after budget growth, as in the early 1980s. The Navy slowly loses force assets during the entire time. The effect on the Air Force is somewhere in-between.

More specifically, the Navy consistently loses relative forces during 20 years of instability, so that its worst case occurs at year 20. The

Army has 40 percent less forces at the midpoint, then starts gaining relatively so that after 20 years it has 10 percent fewer forces than with stable funding. The Air Force had more than 20 percent fewer forces at about year 16, ending with about a 14 percent difference by the year 20.

These differing dynamics depend mainly on two things: the relative magnitude of acquisition budgets as fractions of the total budget, and life-span of the systems acquired.

Recall that acquisitions are forced to absorb most of the changes to a budget. Army acquisitions, which are a relatively small part of the Army total are, therefore, hit hardest by budget changes. Army procurements, which are about of 20 percent of its overall budget, cannot absorb a 5 percent cut in the overall budget as easily as Navy procurements, which are about 40 percent of its budget.

Yet, the Army recovers faster because its systems have shorter life-spans than Navy's 30-year ships. Army systems inactivate more rapidly in the years after budget cuts, leaving less systems to be supported. This, in turn, means more funds from subsequent budgets can be used to rebuild forces. Meanwhile, the Navy is stuck with ships for 2-3 decades.

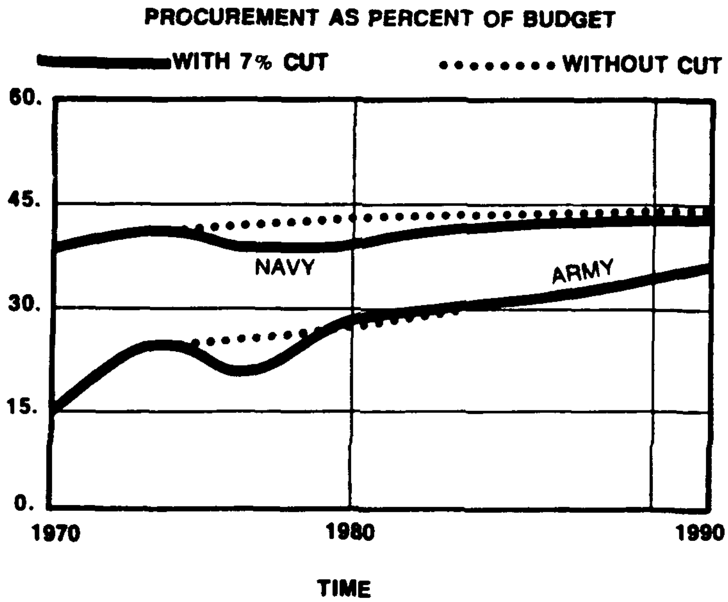
There is another implication. During extreme budget reductions, the Army is likely to be forced to reduce readiness of existing forces. This is because support funds, operations and maintenance funds, and manpower must absorb some budget reductions; procurement budgets are not large enough to do so. The Army industrial base would be too severely affected by amplified swings if a large cut were absorbed totally by procurement. In some years, no procurement funds might remain were ownership accounts not reduced.

One way to see the differing effects of budget changes on the Services is by imposing an arbitrary cut to each Service's top-line budget, and observing results. In Figure 5, the vertical axis represents the fraction of the budget for procurement. Dotted curves are the fraction if budgets grow steadily. Solid curves show the effect of a 7 percent decrease in the fifth year of simulation.

The maximum difference in the Navy curves is about 8 percent. For the Army, the difference is about 19 percent.

Because Army systems can be inactivated faster, after 1980 less funds are required for ownership accounts, so the procurement budget returns and, for a while, slightly exceed its steady growth level. There are less forces to support, leaving more money for procurement.

FIGURE 5. PROCUREMENT DYNAMICS



The Navy, meanwhile, must continue to operate and maintain its *aging fleet, so procurements* do not approach normal levels until at least 25 years have passed.

Policy Implications

Planners can incorporate knowledge of these basic dynamics in long-term considerations of readiness and force levels. Proper budget policy can aid the resource allocation process. Acquisition budgets, specifically, can be realistic. Such strategic budget planning is particularly needed during large budget reductions, as may be the case in the 1990s.

Efficiency can be increased if planners are reasonably sure of next year's budget. That does not mean every program manager needs to know his next year's funding level, which would be unrealistic. Efficiency is gained merely by each Service knowing next year's **overall** constant dollar budget.[3] Then, proper guidance on procurement levels can follow.

Nor is it expected that budgets grow at a steady rate. Knowledge of what the budget **will** be can recapture about two-thirds of losses caused by the uncertainty portions of instability.

Reasonable certainty about next year's budget level can be attained through congressional action. In a 1-year budget cycle, the Congress would need to specify next year's budget before planners start allocation decisions. In a 2-year planning process, the second year of the 2-year plan submitted to

Congress, once the budget is approved, must become the first year of the **next** two year plan to be submitted.

With a realistic top-line budget, planners can derive what will remain for procurement of new systems, as ownership funds demanded by existing forces "next year" is predictable. The cost of operating, maintaining, and manning them is estimable. Support costs, less directly related to force levels, can be estimated in a macroscopic sense.

Individual system acquisitions would vie for available resources. Political and other facts would cause reallocations of available acquisition funds, but reallocations would occur within a reasonable limit. Some programs would gain, others lose from planned levels. Overall, adjustments from the plan would net out to about zero. That is not the case if the entire procurement total is to be decreased or increased by 10-20 percent.

This is a crucial point. When all programs are cut or expanded, resources cannot be shifted easily. When some gain and others lose, on the other hand, gainers can absorb resources given up by losers. Those expanding can, as one example, hire engineers let go by the losers. Not so when everyone is hiring or firing.

Budget stability in the acquisition area can be improved and its significant efficiencies realized.

The Model

A brief look at the simulation model producing these results is appropriate.

The model is preliminary. It captures the major dynamics of resource allocation to provide insight into what can be gained from stability. Most of the first-order dynamics are captured in the current model. Nonetheless, a more detailed model would be appropriate if defense policy-makers wish to assimilate this specific form of dynamic analysis into actual defense planning.

The current model is a microcomputer based simulation written in a commercial software language called Professional DYNAMO+.[4]

It has about 300 lines of code, consistent with a "policy level" model. Policy level means that the large-scale, macroeconomic effects of different allocation policies can be explored. It allows "what-if's." What if fiscal constraints apply? What if readiness is deliberately under-funded? What if inactivations are forced? What if budgets are cut 5 percent a year for several years? What if less manpower intensive forces systems are acquired? These are conducted without bogging down details of specific program allocations.

Important relationships are embedded in the model and can be changed for specific uses. The current model assumes that fiscal constraints apply, that ownership accounts are funded first, but are under funded if procurement residuals are less than a reasonable fraction of that needed to replace inactivating assets. Unit costs are assumed to be impacted by what has been paid for units recently, but only after a lag of several years.

Funding reallocations during times of severe budget reductions are based, roughly, on historical information. Manpower budgets cannot be under-funded by more than 5 percent in a single year, as personnel cannot be forced out more quickly. Operations/maintenance is limited to a 10 percent under-funding per year, and support to 50 percent.

Readiness of available forces is affected when these ownership accounts are under-funded. Backlogs of maintenance and support not funded accumulate, reducing availability. The reduction relationships used are considered reasonable, but have not been and, perhaps cannot, be verified with real data. In results provided above, no backlogs were accumulated at the end of the 20-year periods defined, so readiness shortfalls did not skew the data presented.

During extraordinary budget growth, experienced by all Services in the early 1980s, the industrial base is assumed to be limited in its growth rate. Expert opinion on industrial base growth lead to limiting increasing the overall industrial base to 5 percent, if recent growth had averaged more than 10 percent per year.[5] While individual firms can grow without bound, the defense industry as a whole cannot grow by more than about 30 percent during a short period, without being limited to 5 percent growth the next year. Excess funding during those periods leads to rising unit costs and inefficiency.

ENDNOTES

1. The relationship between unit cost c and quantity q is assumed, in the model, to take the classic form

c=kq**b: where ** means "raised to the power."

This form is then assumed to hold for both planned changes and unplanned changes to budgets, and historiccal data used to estimate the parameters k and b for the two cases. The equation fits the data well for planned changes, and also reflects the **overall** data pattern for unplanned changes. In the latter case, however, there are inconsistencies between the equation and the data in the range of small reductions in quantity, say between zero and ten percent. There, it seems many programs accept reduced funding without

reducing quantities, implying reduced unit costs for that year. This artificial reduction becomes reflected in future cost increases however. Insight into these dynamics has been provided by James Abellera of the Defense Systems Management College, who is currently exploring these relationships in detail.

Using the approximation c=kq**b is nonetheless felt by the author to capture the general effects of budget changes and instability on systems acquisition, and to provide correct perspective on the problem.

The elasticity b for planned changes is estimated to be -.27, and for unplanned changes -.51.

Specific equations used in the model to relate budgets, quantities, and unit costs were

Q=(p/k)**(1/ (1+b)) and
C=KQ**(b); where

P is the ratio of the new procurement to original procurement, Q is the average ratio of new quantity to original quantity, C is the average ratio of new unit cost to original unit cost, K is the initializing constant and b is the elasticity, a negative number. K was near 1.0 for both planned and unplanned changes.

For example, with K=1, if planned budgets equal actual budgets, then P=1 and average unit costs would equal today's levels -- a zero percent change. If procurement is assumed to grow 15 percent because of a five percent increase in the topline budget, then P=1.15 and planned average quantities will increase by 21 percent and average unit costs fall by 5 percent because of the -.27 elasticity factor.

But actual procurement loses the 15 percent assumed increase, average quantities fall by 25 percent, and average unit costs rise from plan by 16 percent because of the -.51 elasticity factor. Instead of the zero percent change to unit costs, they rise a net 10 percent **for this one year.** Unit costs in general then rise, after a lag, if suct inefficiencies persist over time.

2. See Lane Pierrot's "Operation and Support Costs for the Department of Defense", Congressional Budget Office, July 1988.

3. Abellera's work is relevant. The model used here benefits from his analysis, which relates production efficiency for a program on at least three factors: year to year budget changes, changes to the current year's plan, and changes in last year's plan. See the Spending Instability and Acquisition Costs, Proceedings of the 1989 Acquisition Research Symposium, pages 105-111, available from Defense Systems Management College, Fort Belvoir, Virginia, 22060, for some of his preliminary findings.

4. Available from Pugh-Roberts Associates, Five Lee Street, Cambridge, Massachusetts 02139.

5. Dr. Franz Frisch of the Defense Systems Management College provided expert opinion on industrial base issues.

COST GROWTH IN MAJOR SYSTEMS ACQUISITION

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ABSTRACT

This paper is part of a "bottom-up" study of cost growth in defense systems acquisition, focusing on *unit* cost profiles, in constant-year dollars, of DoD programs from all three Services. The paper examines the first sub-sample of eleven systems out of a total sample of some three dozen major programs. It is shown that systems entering the acquisition pipeline early in the acquisition cycle exhibit significantly higher unit cost growth than those entering at or near the beginning of full scale development. It is also shown that management usually does not have a firm hold on unit cost until the last half of the production phase.

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INTRODUCTION

Most large, complex systems--viz, programs involving considerable technical risk, many years in development time and many contractors or subcontractors--usually experience substantial cost growth. This paper is based on partial results of a comprehensive study of cost growth in defense systems acquisition, involving the unit cost profiles, as a function of time, of the following sample of major defense department programs: Patriot, Harpoon, LAMPS, Bradley, F-15, F-16, F-18, Hellfire, HARM, IR Maverick, DSCS III, Peacekeeper, TOW 2, Tacit Rainbow, M-

1, Blackhawk, Apache, Chinook, LHX, MSE, SINGARS, JTIDS, ASPJ, ADDS, T45T, FDS, NAVSTAR GPS, DSP, DMSP, LSD-41 (CV), CVN-68, CG-47, SSN-688, and DDG-51. Preliminary data on a sub-sample of the first eleven systems is now available. This paper is based on an analysis of the unit cost-growth profiles in that sub-sample.

WHY COST GROWTH?

Cost growth is the ratio of the actual program cost of a fielded system to the estimated cost at some earlier reference point in the cycle. Several factors, however, sometimes distort the true cost-growth picture. For example, managers, to keep a program experiencing serious cost growth alive, often reduce the quantity in order to help hold total program cost within politically acceptable limits, thereby moving towards inefficient production rates and further exacerbating the *unit* cost growth. Furthermore, although the Program Manager (PM) budgets for inflation, he does so with inflation factors provided from the outside and at times set by political, rather than economic, considerations. Also, sometimes not all cost elements are captured in the calculation of program cost, with R&D cost and system-specific construction cost being common escapees. In addition, as a system experiencing cost growth moves through the acquisition cycle, the apparent intensity of its cost growth may be dampened by moving the reference point and associated base cost estimate to later positions in the cycle.

In this study the unit cost, at any point in time, is taken as the total program cost estimate (the sum of research, development, production and system-specific military construction cost) at that point divided by the total estimated number of units to be bought during procurement *and* R&D. The cost is in constant-year dollars, although the base year varies with the program. The reference base estimate is taken as that provided at the point of the system's entry into the acquisition pipeline.

Why do we often have cost overruns? In the most general sense, because we have great difficulty estimating the true cost of future new developments. Obviously, the more complex the new system, the closer to the cutting edge of technology and the more distant in time the delivery of the final product (i.e. the longer the forecasting horizon), the higher the estimating error is likely to be.

PRELIMINARY RESULTS

The programs analyzed in this study fall into two basic categories: (1) those that, following the guidance of the Defense Department's top-level policy document (DODD 5000.1), entered the acquisition pipeline--namely, the intense scrutiny of the Office of the Secretary of Defense and Congress--at or near the beginning of the concept exploration/definition phase; and (2) those that entered the pipeline much later in the cycle, usually at the beginning of the full scale development phase, either because they predated the 5000.1 requirement or because they were treated as exceptions in this regard (and were managed within the Services). Six major systems in the sample considered in this paper, fall into Category I; the remaining five, into Category II.

The programs in Category I, experienced no-cost growth in the concept exploration/definition phase, and on average incurred a unit cost growth of 31% in concept demonstration/validation, 46% in full scale development, and 42% in production for a total unit cost growth of 119%.

The programs in Category II, on the other hand, exhibited an average unit cost growth of 22% in full scale development and 36% in production, for a total of 58%.

Virtually all systems in both categories experienced difficulties in transitioning from full scale development to production. These difficulties accounted for an average unit cost growth of about 25% during the early part of the production phase.

Theoretically, the cost estimating error should be symmetrical in the sense that when dealing with a relatively large number of systems (which is the case in DoD), we should have approximately as many cost underruns as we have overruns. In practice, as demonstrated by our sample, this is obviously not the case, cost overruns usually being the rule, with the asymmetry stemming from a fundamental bias in the estimating process, sometimes referred to as the "conspiracy of optimism."

As the system progresses through the acquisition cycle, the program manager gains increased visibility into its ultimate cost, and the system "accumulates" cost growth. In a resource constrained environment, a significant increase in program cost can threaten the very survival of the system. Thus, it is not surprising that in our sample each jump in unit cost was accompanied by program changes which tended to soften the impact of the cost overrun. Several of these were discussed earlier. The others fell into one or more of the following categories: (1) a decrease in the capability or effectiveness of the system (e.g. reduction in the number of spares and/training devices, deletion of or decrease in interoperability and/or electronic countermeasures, deletion of provision for nuclear warhead, reduction of integrated logistic support), (2) a decrease in the survivability of the system (e.g. deletion of nuclear/biological/chemical (NBC) protection for humans, decrease in electronic counter-countermeasures); (3) "creative" accounting (e.g. not counting the government furnished equipment (GFE) against the program, moving some of the units to the "out-years"); (4) innovative concepts (e.g. changes in fielding concept, revisions of maintenance concept); and/or (5) luck (e.g. beneficiary of foreign military sales).

COLLATERAL DAMAGE DIMENSION

Obviously, a program experiencing cost growth imposes a direct burden on the acquisition process in that we have to "find" the additional resources to cover the overrun. But perhaps far more important is the indirect penalty, or collateral damage, that such a program inflicts on the rest of the systems in the acquisition pipeline, by setting up a ripple effect that destabilizes the entire acquisition process. To keep such programs intact, funds must be taken away from other programs. This sets off a chain reaction wherein the schedules of the other programs are stretched in order to accommodate their reduced funding profiles, and these delays in turn give rise to changes in threat projections, requirements, and performance--all of which in turn generate additional cost overruns for the affected systems.

The systems in Category I had significantly higher overruns, even after taking into account the differences in forecasting horizons and the relative magnitudes of the reference cost bases. Since selection for entry into the acquisition pipeline, from among competing potential candidates, is usually based on trade-offs among cost, schedule and performance, the systems in Category I appeared much more attractive at the point of entry than they ultimately turned out to be--and more attractive than they would have been had they competed for entry later on in the cycle when much greater visibility into their ultimate cost growth became available. In a sense, they therefore received an "unfair" advantage (relative to other more "mature" systems competing for entry) and probably squeezed out some more meritorious candidates, thus providing a lower return on the defense dollar.

TERMINATION/CANCELLATION OPTION

Since the government, as a sovereign, has the right to terminate or cancel contracts for the convenience of the government, some experts have suggested that this mechanism be used for reducing the collateral damage caused by cost overruns. The approach would be to prioritize all programs and fully fund only as many as we can afford. However, when all other benefits and costs are taken into consideration--i.e. when we factor in the benefits of a mix of weapons in the combat environment as well as the "political" cost of cancelling programs in a pluralistic democracy such as ours--DoD frequently finds it more cost effective to terminate fewer systems than one might expect.

CONCLUSIONS

Many major defense programs experience significant cost growth. Thus, we usually have many more systems in the acquisition pipeline than we can effectively and efficiently handle. Cost growth, therefore, becomes a central problem which feeds on itself and from which many other acquisition problems stem.

All programs in the sample experienced substantial unit cost growth as they moved through the acquisition cycle. Those entering the acquisition pipeline early in the cycle experienced, on the average, much higher unit cost growth than those entering at the start of full scale development. But what is perhaps more important is that the systems in the former category probably had an unfair relative advantage in competing for entry into, and remaining in, the acquisition pipeline, thereby squeezing out more meritorious candidates and providing the taxpayer with a lower return on his defense dollar.

All programs experienced difficulty in transitioning from FSD to production, with the difficulty translating into an average unit cost growth of about 25% in the early part of the production phase. Management does not have a good hold on unit cost until well into the production phase.

INDUSTRIAL PREPAREDNESS

USING INFORMATION SYSTEMS TO IMPLEMENT INDUSTRIAL PREPAREDNESS POLICIES

by

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ABSTRACT

Industrial preparedness (IP) planners are responsible for establishing and implementing policies, programs, and procedures to ensure that we have a viable and responsive domestic industrial base to meet our national security needs. The planning process is part of the larger acquisition process that includes contracting, logistics, maintenance, and quality assurance. While it is generally recognized that the acquisition community is made up of numerous interrelationships, the sharing of resources among its members has not been fully exploited. This is particularly true regarding the sharing of information resources. IP planners tapping into databases managed by others in the acquisition community could use acquisition data for, among other things, monitoring the industrial base, determining how best to implement IP policies, and evaluating how well these policies are being carried out.

This paper examines an IP effort that capitalizes on databases found throughout the acquisition community. The Defense Industrial Network (DINET) serves as an analytical tool for monitoring the U.S. defense industrial base in support of the IP program.

Through the merging, processing, and refining of selected data from multiple databases, new information can be used by decision-makers for answering contractor, weapon system, and product-specific questions. This information includes, for example, how much and how quickly material can be produced by specific manufacturers during peacetime and emergency situations. It is necessary for decision-makers to know the constraints on increased production and options available for alleviating those contracts, thus increasing the capabilities of the base.

A key function of DINET is its ability to show (currently, only a *limited* view) the existence of sole and foreign sourcing among critical lower tier suppliers and the relationship lower tier suppliers have to more than one weapons system. Such information not only provides a clearer perspective of the domestic industrial base, but also serves as a source in resolving related problems as foreign dependency. Another function is locating alternative producers, a prime consideration in making mobilization base procurement restriction determinations and useful information during peacetime to increase competition and lower acquisition costs.

While no single database has been developed that can give complete answers to any of the current concerns or to others that IP planners may face in the future, the issue of existing Government databases integrated through the DINET

provides a tool to track significant industrial base activity trends. While DINET has not yet achieved its goal, it has made impressive strides in becoming a one-stop shop for illuminating segmented views of the defense industrial base.

INTRODUCTION

Background. The acquisition process has become increasingly complex with regard to changes in threats, weapon system production cutbacks and cancellations, and challenges to industrial and military readiness in support of operations such as "Desert Storm." The fall of communism in Eastern Europe accompanied by the easing of tensions with the Soviet Union has led to a questioning of many of our threat scenarios and the impacts these scenarios have on the industrial base.

These events have been closely monitored by industrial preparedness planners, charged through statutes to develop and implement an industrial preparedness program to meet the expanded production demands of a national security emergency. National Security Decision Directive 47 establishes a policy to establish and maintain a capability to mobilize industry and to achieve production of essential materiel to support a major military conflict. Executive Order (EO) 12656 requires the Secretary of Defense to develop plans and programs to mobilize equipment, facilities, and other resources; to develop emergency plans and programs as an integral part of normal activities; and to develop with industry, government and the private sector reliable capabilities for a rapid increase of defense production. This EO was enforced by the National Defense Authorization Act of 1989 that requires the Secretary of Defense, through the Under Secretary for Acquisition, to provide policy and direction to the military departments and defense agencies relating to maintenance, expansion and readiness of the defense industrial base; to analyze defense industrial base capabilities to meet national security requirements of peacetime and war; and to develop and direct plans, programs and policies to promote the ability of the defense industrial base to meet national security requirements.

A number of DoD directives and instructions directly implement the industrial preparedness program. Among those are:

- o DoDD 4005.1 Industrial Preparedness Program. Formalizes policy and procedures requiring planning and management actions to maintain industrial preparedness to meet emergency production requirements.

- o DoDD 4200.15 Manufacturing Technology Program. Establishes the manufacturing technology program that ensures the availability of advanced manufacturing processes, techniques and equipment to support DoD acquisitions and promotes capital investment and industrial innovation in new plant and equipment, among other things.

Changing political and military conditions have affected the way industrial preparedness planners do their business. Instead of developing policies and implementing programs based on a flat or an expanding procurement scenario, they must now evaluate what impact reductions

in weapon system procurements will have on the defense industrial base. This is a significant change, and it has major ramifications as to how industrial preparedness planning is performed and the role it plays in the larger acquisition process that includes contracting, logistics, maintenance and quality assurance.

Under the umbrella of reorganizations and redefining roles and processes, an opportunity exists to improve information resource sharing. A wide array of databases supporting program functions, whether they be contracting, cataloging, quality assurance, etc., contain information useful in industrial preparedness planning. Procurement and logistics databases contain information that would assist IP planners to better monitor the industrial base, determine how best to implement IP policies, and evaluate how well these policies are being carried out. Contracting data can highlight major/critical contractors producing components for weapon systems. And, competition information can be useful in identifying items dependent on sole or foreign sources.

Scope. This paper examines an IP effort to merge, process, and refine selected data from multiple databases for use in industrial preparedness planning and program analysis. The Defense Industrial Network (DINET) can serve as an analytical tool for monitoring the U.S. defense industrial base in support of the IP program.

Once fully developed, DINET will be able to assist decision-makers in answering contractor, weapon systems, and product specific questions. This includes, for example, how much material can be produced and how quickly during peacetime and emergency situations? Decision-makers need to know where the constraints to increased production are and what options exist for alleviating those constraints. Such information not only provides a clearer perspective of the domestic industrial base but also serves as a source in resolving related problems. For instance, the ability to locate alternative producers is a prime factor in determining a mobilization base procurement restriction and can be used during peacetime to increase competition and lower acquisition costs.

While no single database has been developed that can completely answer any of these concerns, accessing information contained in existing Government databases integrated through the DINET provides a tool to track significant industrial base activity trends. While DINET has not yet achieved many of its goals, it has achieved impressive strides toward becoming a single source for illuminating segmented views of the defense industrial base.

In this paper we will discuss the six IP functional areas that form the core of DINET information, the status of its development, the databases that are currently accessed, and examples of how it can support industrial preparedness planning and program implementation.

Six Functional Areas. Industrial preparedness planning involves ensuring that the domestic industrial base is capable of efficient peacetime production and a range of production responses to a wide variety of possible contingencies under emergency situations. Accomplishing this goal requires timely access to information to support the

formulation and implementation of coherent industrial base policies.

Once fully developed, DINET, as an analytical support system, will help management address the following six IP functional areas:

- o acquisition, mergers and takeovers;
- o sole, single, diminishing and foreign dependencies;
- o government policy and the industrial base;
- o surge, mobilization and the industrial base;
- o the ability to respond to/recover from natural disasters; and,
- o critical technologies, military technology leadership and the industrial base.

These functional areas represent many of the concerns/issues that IP planners must address. These areas also show the requirement for interaction between IP and the rest of the acquisition community. Merging domestic firms may reduce competition to a level where a limited number of companies control the marketplace and price.

Evaluating the degree of competition involves looking at major competitors (both foreign and domestic); the market share each competitor holds; how well each competitor meet our current needs; and the probability that each competitor will/can meet our future peacetime and emergency needs. Foreign acquisitions of domestic firms raises concerns over future production capabilities, R&D commitment and direction, and technology transfer as well as the potential reduction of competition.

Since foreign sourcing of critical items does exist, monitoring for foreign dependency or vulnerability is essential. Sole and single source as well as diminishing manufacturing sources also raises concern over reduced competition.

Developing and implementing procurement policy involves considering the scope of a given policy on DoD procurement and the overall impact it may have on procurements. This entails, for instance, determining the percentage of procurement that may be affected by a specific policy.

Analysis of industrial production addresses both plant-specific and industry-wide capabilities, including maximum production capacity, surge capability, production constraints, and special manufacturing processes.

Responding to natural disasters requires identifying the locations of production sources, weapon systems affected by the lost or reduced capacity/capability of those sources and alternative suppliers.

Analyzing U.S. military technological leadership and its effect on the industrial base raises important questions regarding how well we compare to our competitors now and predictions regarding our future technological standing.

In addressing these functional areas, we developed questions to gain a better understanding of the issues while recognizing that external conditions (i.e.,

political, cost, etc.) also play a key role in addressing the IP functional areas. More simply stated, the six functional areas are highly complex requiring multiple inputs to the decision-making process, with DINET serving as only one source. After reviewing these questions, we realized that there are sixteen questions common to each area. These sixteen questions form the basis for the core information to be included in DINET:

1. What items does DoD buy, either directly or indirectly?
2. What is the relationship of those items to each other and to weapon systems?
3. What is the demand for the item?
4. What is the item's technical and military importance?
5. Are substitute items available?
6. Who is selling to DoD directly and indirectly?
7. What is the relationship between prime and subcontractors, and upper and lower tier subcontractors?
8. Which suppliers are single, sole, and foreign sources?
9. Are substitute suppliers available?
10. What is the parent firm's name and location, and who owns the parent firm?
11. What is the location for each plant in question and the location of their competitors?
12. Are any of the plants in question certified to produce military critical technology?
13. What is the capacity/leadtime/ quality record for the firms in question and what are the trends?
14. What percentage of output is dedicated to each service for the firms in question?
15. What are the capabilities (i.e., special manufacturing processes) for the firms in question?
16. Are the firms in question planned producers for industrial mobilization?

THE DEFENSE INDUSTRIAL NETWORK

DINET permits users to access and compile industrial base data for analytical purposes. To understand DINET's capabilities, we will discuss how it supports assessments in the six functional areas.

Technical Design. DINET was designed using the Computer Corporation of America's MODEL 204 database management system. MODEL 204 databases are structured to provide a very high degree of flexibility, data independence and retrieval efficiency. MODEL 204 also offers an unusually versatile, self-contained user language for custom queries requiring no background in programming. DINET is housed on an IBM 3080 computer mainframe located at the Defense Logistic Agency's Administrative Support Center, Cameron Station in Alexandria, Virginia. Access is

gained through the use of a personal computer, a modem, and communications software that, when connected to the mainframe, turns the PC into a dumb terminal during data transmissions.

Data Sources. DINET currently receives data from fourteen databases with input from additional sources planned for the near future. The majority of the databases are managed by the Defense Logistics Agency, while others are from the Departments of Commerce and Labor. Appendix A lists the information sources, programs the support, and frequency of update.

Current Status. DINET was originally developed as a prototype. Work is now underway to include additional data to provide a more complete view of the defense industrial base. If we had to rate the coverage and quality of data currently in DINET, it would look like this:

TOPIC	COVERAGE/ QUALITY
Prime Contractors (contracts > $25,000)	- Excellent
Subcontractors	- Limited
Weapon Systems (prime contractor support)	- Excellent
Components (sourcing for contracts > $25,000)	- Excellent
Locations of Prime Contractors (for contracts > $25,000)	- Excellent
Locations of Subcontractors	- Limited
Foreign Sourcing (prime contractors with contracts > $25,000)	- Excellent
Foreign Sourcing (subcontractors)	- Limited
Sole Sourcing (prime contractors with contracts > $25,000)	- Excellent
Sole Sourcing (subcontractors)	- Limited

Program Implementation. DINET allows the user the option of accessing data for each of the past five years or on an aggregate basis. The system comprises two modules: the Supplier Module (Appendix B) and the Procurement Module (Appendix C). the Supplier Module provides information on firms (both domestic and foreign) that supply goods and services directly and indirectly to the Department of Defense. The Procurement Module, on the other hand, focuses on information relating to weapon systems, the geographic location of sources and item sourcing.

A valuable attribute in DINET is its ability to allow the user to obtain a contractor or weapon system code in order to perform queries on a contractor or a weapon system. This saves extensive time spent manually researching a coding book.

Let's now briefly review DINET's menu options. The Commercial and Government Entity (CAGE) code query is the first option in the Supplier Module. Large firms often have multiple business units that receive DoD contracts. Many times we need to know information about the actual business unit supporting DoD rather than the parent firm to better understand the capabilities of the source providing the products and services. General Dynamics, for instance, has over 100 business units identified by individual CAGE codes. General Dynamics Land Systems (GDLS) division is building the M-1 Tank, so it is better to use GDLS' CAGE code rather than the corporate CAGE code for General Dynamics.

Through the Contractor Query, we are able to obtain CAGE codes for a company's business units as well as the corresponding DUNS (Dun and Bradstreet) number, the corporate CAGE code, the primary Standard Industrial Classification (SIC) code, the number of personnel employed, the eligibility status for receiving DoD contracts (eligible, suspended, debarred), the type of business performed (manufacturer or distributor), and the address and phone number.

Supplier Profile is the second option on the DINET Supplier Module Menu. This option provides a summary of components that the firm directly and, to a lesser extent, indirectly sells to the Department of Defense. This option provides the following information:

- o The firm's parent company
- o Certification to produce military critical technology (if applicable)
- o The number of prime contracts over $25,000 award by Service/Agency and the contract dollar amounts
- o Components provided through direct purchases
- o Weapon systems supported through direct purchases of components
- o Contracts awarded under other than full and open competition
- o Items for which the firm is sole source
- o Items for which the firm is a foreign source through direct purchases
- o Components provided through indirect purchases (limited coverage); and,
- o Items for which the firm is a foreign source through indirect purchases.

Supplier Commitment is the third option on the Supplier Module Menu. This option provides specific information on a firm's direct and indirect (limited coverage) sales to DoD as well as individual contract numbers and dollar amounts, components purchased, and the weapon system that the contracted item is supporting.

Corporate Firm Profile is the fourth option on the DINET Supplier Module Menu. This option provides information about the relationship between a corporate headquarters and its subsidiaries.

Plant Profile is the fifth option on the Supplier Module Menu. This option provide plant specific data regarding:

- o Dollar value of output;
- o Output as a percentage of the total industry capacity for those firms surveyed by the Department of Commerce;
- o Primary commodity; and
- o Special manufacturing processes.

Contract Number Query is the sixth option on the Supplier Module Menu. This option provides information regarding individual contract actions as recorded on the DD Form 350, Individual Contracting Action Report (over $25,000).

Procurement Module. The second module in DINET is the Procurement Module which contains profiles of weapon systems components, geographic locations of both domestic and foreign firms, and foreign direct investment.

Contractor Query is the first option on the DINET Procurement Module Menu. This option is the same as in the Supplier Module Menu and is provided in this module as a convenience.

Weapon System Profile is the second option on the DINET Procurement Module Menu (Appendix D). This option provides information about companies that supply products and services supporting weapon systems. You can also obtain a system code necessary to query the system for information about weapon systems containing components supplied by companies that are produced both here and abroad as well as those firms that are a sole source for a product or service.

Item Profile (Appendix E) is the third option on the DINET Procurement Module Menu. This option provides you with specific information about an item, its relationship to a weapon system(s), and its supplier(s). Information can be obtained by part number, Federal Supply Class (FSC), SIC code, National Stock Number or military specification/standard. This option also identifies items purchased from only one source, items produced in a foreign country, items purchased under other than full and open competition, and the contract number under which the item was purchased.

The Geographic Query (Domestic) is the fourth option on the DINET Procurement Module Menu. This option provides information regarding the locations of DoD suppliers in the United States, the products and services they provide, and the weapon systems they support.

The Geographic Query (Foreign) is the fifth option on the DINET Procurement Module Menu. This option provides information regarding firms supplying products and services directly to DoD from plants located in foreign countries.

Foreign Direct Investment Queries is the seventh option on the DINET Procurement Module Menu. This option provides you with historical information regarding investments that foreign-based companies have made in the U.S industrial base. Although DINET only contains data up to 1987, current data is expected to be available shortly. This information can be sorted by country, industry, or investment type.

National Stock Number Query is the eighth and last option on the DINET Procurement Module Menu. This option allows you to obtain specific National Stock Numbers (NSNs) , their respective part number, and sources.

DINET AS AN ANALYTICAL TOOL

DINET provides industrial preparedness planners with information necessary for developing, implementing and evaluating policy for ensuring that the domestic industrial base is capable of efficient peacetime production and a range of production responses to a wide variety of possible contingencies under emergency conditions.

Although DINET is not fully developed and therefore data shortfalls exist, sufficient data is available to assist industrial preparedness planners in addressing the six functional areas that form the core of the system.

Acquisitions, Mergers and Takeovers. In assessing the potential impact that a foreign acquisition of a domestic firm may have on the industrial base, one would begin by querying the Supplier Profile Menu Option. This provides information on the relationship that the firms involved have with the DoD. From this profile, we can identify: firms certified to produce/maintain critical military technology; the Services/Agencies that purchase their products or services; the components purchased; the weapon systems that are supported by these components; classified contracts awarded; contracts awarded under other than full and open competition and the reason(s) why; and instances of sole or foreign sourcing.

Using this information along with that provided in the filing under the Committee on Foreign Investment in the United States procedures, we can make a determination as to the probability that the industrial base may be harmed by the takeover or whether additional scrutiny is required. For instance, the Defense Investigative Service may need to be contacted regarding possible classified contracts being awarded to the takeover target or the contracting officer may need to be contacted regarding the potential impact to competition.

Sole, Single, Diminishing, and Foreign Dependencies. DINET can help identify areas of supply shortfalls or vulnerabilities plus assist in locating potential sources.

In identifying areas of sole, single, diminishing sources, and foreign dependencies, query the Supplier Profile Menu Option of the Supplier Module to identify components in which a supplier is the sole source or furnishing the item from abroad. One can also query the Item Profile Menu Option of the Procurement Module to identify items provided by a sole source, single source, or foreign source. Accessing the Weapon Systems Profile Menu Option of the Procurement Module allows one to identify those components that DoD buys directly through sole, single, or foreign sources. Another option is to look at the Plant Profile Menu Option of the Supplier Module to identify those firms that produce a significantly high percentage of the commodity for those plants that were surveyed. For instance, you may query XYZ Corporation and find that they produce 95% of the products that were surveyed for SIC XXXX. You can then assume that there are limited sources for this commodity.

To locate additional sources, whether they be domestic or foreign, one would access the Item Profile Menu Option of the Procurement Module and query either by FSC or SIC. DINET displays sources across Service/Agency lines. This is an important capability. For instance, the Air Force may be buying a bearing from one source for a leading gear unaware that others exist. The Navy could be buying from a source different from the one used by the Air Force. Knowing both sources could help improve competition and capacity needs.

Another method of identifying additional sources is on an item specific basis through the National Stock Number Menu Option under the Procurement

Module. By entering the FSC and commodity name, DINET provides all related NSNs and sources. For instance, if one wanted potential sources for chemical protective suits, enter the FSC 8415, Clothing Special Purpose and "chemical protective suit". DINET would provide the names of contractors who, in the past, have provided the suits.

Government Policy and the Industrial Base. DINET can provide information useful in developing or implementing government policy. For instance, DINET can provide insight on how well certain policies are being implemented. In looking, for example, at the congressionally mandated machine tool restriction, query the Item Profile Menu Option of the Procurement Module by each FSC restricted for all contracts in, say, 1989. Then query by each FSC to identify those contracts that were recorded as restricted under less than full and open competition. By subtracting the second list from the first line, the remaining contracts are now suspect as not being restricted and further research is necessary to see if the solicitation was waived, the DD Form 350 was incorrectly filled out, or that the Contracting Officer erred in not restricting the procurement.

Surge, Mobilization, and the Industrial Base. DINET is limited in what it currently can show in this area. Efforts are being made to collect plant capacity and capability information. Accessing the Plant Profile Menu Option under the Supplier Module will allow you to identify by SIC code the production output (in dollars) of plants surveyed by the Department of Commerce plus the plant output as a percentage of total production output (in dollars) of these plants. From this information, one can identify the major producers for an industry and contact them to determine their surge and mobilization capabilities.

The Ability to Respond To/Recover From Natural Disasters. DINET can provide the locations of firms supplying goods and services to the DoD by county and locality. It can identify the types of goods and services and the weapon systems they support. Additionally, DINET can identify producers who are not affected by the disaster and who may be able to serve as substitute sources until the affected sources are able to restore their manufacturing capabilities and capacities.

Critical Technologies, Military Technology Leadership, and the Industrial Base. DINET can identify those firms that are certified to receive critical military technology. Queries can then be made to the firm to see the types of technologies with which they are involved.

SUMMARY

The acquisition process, in becoming increasingly complex, greatly influences the way industrial preparedness planners conduct their business. Under the changing world political and military situations, the acquisition community has undergone reorganizations and a redefining of roles. An opportunity exists under this climate to press for improved sharing of information resources. The Defense Industrial Network (DINET) serves as an analytical tool for monitoring the U.S. defense industrial base by merging, processing, and refining selected data from multiple information systems, each developed from a specific program function unrelated to industrial preparedness.

In this paper, we have addressed the six functional areas that serve as the informational core of DINET and discussed issues/questions that are common to each area. Although DINET is not yet fully developed, it has sufficiently advanced to give legitimate promise to the concept of a database that can assist in the implementation of the industrial preparedness program.

Notes:

1. Material contained in the DINET User's Handbook 15 January 1991 was used in support of this paper.

2. Work by Mr. Rod Vawter on statutes, guidelines and procedures relating to industrial preparedness was used in this paper.

DEFENSE INDUSTRIAL NETWORK (DINET) INFORMATION SOURCES

INFORMATION SOURCES - CURRENT (CONSTRAINTS TO ACCESS)	PROVIDING ACCESS	INFORMATION USAGE	FREQUENCY OF UPDATE
1. Current Acquisition Activity (DD350)	Defense Logistics Agency (DLA) U.S. Department of Defense	a. Obligations and deobligations over $25,000 b. Current suppliers of a product c. FSC/SIC crissref to alternate suppliers in CAGE d. Contract place of performance e. Government regulations applied to purchase f. Foreign sourcing and foreign military sales information g. Services (purchasing office of the product) h. Weapons systems supported	Quarterly
2. Contractor and Government Entity (CAGE)	Defense Logistics Agency (DLA) U.S. Department of Defense	a. Producers and their locations b. CAGE number/DUNS number cross reference c. Major SIC codes d. Alternate suppliers based on SIC code	Nightly
3. Register of Planned Emergency Producers (PEPM and PEPROC)	Defense Logistics Agency (DLA) U.S. Department of Defense	a. Emergency producers and their locations b. Armed Services Production Planning Officers (ASPPOs)	Daily On-line

DEFENSE INDUSTRIAL NETWORK (DINET) INFORMATION SOURCES

INFORMATION SOURCES - CURRENT (CONSTRAINTS TO ACCESS)	PROVIDING ACCESS	INFORMATION USAGE	FREQUENCY OF UPDATE
4. Foreign Direct Investment Data Base (FDI)	Office of Trade Investment and Analysis U.S. Department of Defense	a. Foreign direct investment transactions in the U.S. b. Foreign investment of industry or state locations c. Foreign investment by investor country d. Type of investment	Annually
5. Qualified Contractor Access List (QCAL)	Defense Logistics Agency (DLA) U.S. Department of Defense	a. Contractors certified to be given access to critical military technology	Semi-Annually
6. Quality Assurance Date Base (QUADS)	Defense Logistics Agency (DLA) U.S. Department of Defense	a. Contracts performed at a specific facility b. Quality of performance at the facility c. Periodicity and methodology of quality assurance	Monthly
7. Federal Information Processing Standards (FIPS)	National Bureau of Standards U.S. Department of Defense	a. Country b. State c. Place d. Zip e. Congressional districts	Annually

DEFENSE INDUSTRIAL NETWORK (DINET) INFORMATION SOURCES

INFORMATION SOURCES - CURRENT (CONSTRAINTS TO ACCESS)	PROVIDING ACCESS	INFORMATION USAGE	FREQUENCY OF UPDATE
8. Duty-Free Entry Data - CUSTOMS	Defense Logistics Agency (DLA) DCASR - New York U.S. Department of Defense	a. Contracting entity of DoD entity making purchase b. Product, country or origin, value, destination s' ;, quantity c. TSUSA description	Quarterly
9. Duty-Free Entry Data - DUTYPIIN	Defense Logistics Agency (DLA) DCASR - New York U.S. Department of Defense	a. Prime/subcontractor information b. Total contract dollar amount c. Contract number	Quarterly
10. DUNSDOD (Proprietary)	Defense Logistics Agency (DLA) Office of Industrial Base Assessments (OIBA) U.S. Department of Defense	a. Facility location b. Major SICs of facility c. corporate structure d. Information on how to contact the company	Quarterly
11. Federal Supply Classification (FSC)	Defense Logistics Agency (DLA) U.S. Department of Defense	a. Cross reference from FSCs to industries (SICs) b. FSC description	As Needed
12. Standard Industrial Classification (SIC)	Defense Logistics Agency (DLA) U.S. Department of Defense	a. Cross reference from SICs to products (FSCs) b. SIC description	As Needed

DEFENSE INDUSTRIAL NETWORK (DINET) INFORMATION SOURCES

INFORMATION SOURCES - NEAR TERM (CONSTRAINTS TO ACCESS)	PROVIDING ACCESS	INFORMATION USAGE	FREQUENCY OF UPDATE
1. Plant Inventory File (Inventory Access)	Joint Data Systems Support Center U.S. Department of Defense	a. Facility locations b. Facility Lat/Long c. Predominant SICs d. Percent of industry total	Annually
2. Federal Supply Catalog Master Cross Reference List - Consolidated (MCRL-C) a. Reference Number Sequence b. National Item ID Number (NIIN) Sequence c. Commercial and Government Entity (CAGE) Sequence	Defense Logistics Services Center U.S. Department of Labor	a. Comprehensive list of National Stock Numbers (NSNs), reference numbers, and manufacturers codes cross-referenced to each other b. Supplemental procurement information	Quarterly

APPENDIX B

DINET - SUPPLIER MODULE

1. CONTRACTOR QUERY - TO OBTAIN CAGE CODE
2. SUPPLIER PROFILE - DIRECT AND INDIRECT SALES TO DOD (SUMMARY)
3. SUPPLIER COMMITMENT - DIRECT AND INDIRECT SALES TO DOD (ITEMIZED)
4. CORPORATE FIRM PROFILE - FIRMS SUPPORTING DOD
5. PLANT PROFILE - FACILITIES PRODUCING FOR DOD
6. CONTRACT NUMBER QUERY - INFORMATION ON INDIVIDUAL CONTRACTS
7. RETURN TO MAIN MENU

ENTER MENU SELECTION NUMBER

FIGURE 1. DINET SUPPLIER MODULE MENU

APPENDIX C

DINET PROCUREMENT MODULE MENU

1. CONTRACTOR QUERY - TO OBTAIN CAGE CODE
2. WEAPON SYSTEM PROFILE - COMPANIES SUPPORTING A WEAPON SYSTEM
3. ITEM PROFILE - ITEM RELATIONSHIP TO A SYSTEM
4. GEOGRAPHIC QUERY (DOMESTIC) - LOCATION OF FIRMS SUPPORTING DOD
5. GEOGRAPHIC QUERY (FOREIGN) - LOCATION OF FIRMS SUPPORTING DOD
6. SPECIAL QUERIES -QUERY THROUGH PROGRAMMING LANGUAGE
7. FOREIGN DIRECT INVESTMENT QUERIES
8. NSN QUERY - TO OBTAIN NATIONAL STOCK NUMBER
9. RETURN TO MAIN MENU

ENTER MENU SELECTION NUMBER

FIGURE 2. DINET PROCUREMENT MODULE MENU

APPENDIX D

WEAPONS QUERY MENU

1. WEAPON SYSTEM CODE QUERY - TO OBTAIN WEAPON CODE
2. DISPLAY INFORMATION BY SYSTEM CODE
3. DISPLAY INFORMATION BY FSC CODE
4. DISPLAY INFORMATION BY BOTH SYSTEM CODE AND FSC CODE
5. DISPLAY INFORMATION BY SIC CODE
6. DISPLAY INFORMATION BY NSN (* FUTURE DEVELOPMENT *)
7. DISPLAY EVIDENCE OF FOREIGN SOURCING
8. DISPLAY EVIDENCE OF SINGLE SOURCING (* FUTURE DEVELOPMENT *)
9. DISPLAY EVIDENCE OF SOLE SOURCING
10. RETURN TO PROCUREMENT MENU

ENTER MENU SELECTION NUMBER

FIGURE 3. WEAPONS QUERY MENU

APPENDIX E

ITEM PROFILE MENU

1. DISPLAY INFORMATION BY COMMODITY CODE (SUBTIER INFORMATION)
2. DISPLAY INFORMATION BY PART NUMBER
3. DISPLAY INFORMATION BY FSC CODE
4. DISPLAY INFORMATION BY 4-DIGIT SIC CODE
5. DISPLAY INFORMATION BY NSN
6. SUMMARY (INCLUDES EVIDENCE OF SINGLE, SOLE AND FOREIGN SOURCING)
7. DISPLAY INFORMATION BY MIL SPEC/MIL STANDARD
8. RETURN TO PROCUREMENT MENU

ENTER MENU SELECTION NUMBER

FIGURE 4. ITEM PROFILE MENU

INTERNATIONAL ASPECTS

of ACQUISITION

INTERNATIONAL PROGRAMS: THE NEXT GENERATION DSMC 1990-91 MILITARY RESEARCH FELLOWS

ABSTRACT

Defense acquisition has entered a new and exciting era. Just as quickly as peace broke out and the "wall" came down, the Gulf Crisis broke out. The need for international cooperation was never clearer.

In this new era of declining defense budgets and reduced force structure, international defense ministries will interface more in the future. New business approaches to acquiring weapons will be required. The need will be to get more "bang for the buck" through harmonizing requirements, capitalizing on global technology, and economizing global production capacity.

It is clear from prior studies that, in the past, U.S. international programs have generally been limited to Foreign Military Sales (FMS) and direct sales of U.S. military products to allied nations. This predominantly one-way flow of military products is no longer acceptable in the new era.

Previous studies of international program management have focused on governmental perspectives regarding success and failure. Success has been linked to a strongly shared sense of common mission, a harmony of requirements, strong PM authority, and effective steering groups. Barriers to success were found to include geography, language, cultural difference, unclear Memorandum of Understanding (MOU), and a lack of strong sponsor support.

This paper examined the international program initiation process. Among the major findings are the importance of goal congruence, commitment, technology exchange, trust, industrial benefits, and reducing the administrative burdens.

Goal congruence is the very foundation of a successful program; without it, there is no chance for success. The U.S. must be more selective in its multi-national programs and then commit to them for the long haul. Technology controls must be updated to reflect the technology stature of our allies. Other nations no longer want to be merely a buyer of U.S. products; they demand a share in the industrial benefits associated with developing, producing and supporting a weapon system.

The world political and economic order has changed. Regardless of how admirable the goal, no nation can afford the cost of self-sufficiency in defense. This paper does not advocate international programs as the newest fad in program management; it is not a panacea. However, where it "fits," an international program can present some significant advantages to all of the participants: economies of scale in development and production; acquiring a new technology or weapon system for cents-on-the-dollar; intellectual synergy; foreign market access; and, greater interoperability among the United States and its allies.

INTERNATIONAL CALS -- INTERNATIONAL FUTURE

by Rowland G. Freeman III, Management Consultant

ABSTRACT

Computer Aided Acquisition and Logistics Support (CALS) is a joint Department of Defense and Industry Strategy for the transition from paper intensive processes to highly automated integrated processes for weapons system acquisition, design, manufacturing and life cycle support. The key elements of the strategy are:

- Standards and technology
- Acquisition guidance and incentives
- DoD infrastructure modernization

CALS implementation in the United States has centered around the work of the joint DoD/Industry Steering Committee and the DoD CALS Office. Individual work arrangements have been delegated to subordinate committees, subcommittees, and task working groups. As committee members, subcommittee members, and technical specialists struggle with task oriented assignments there has developed, if not real progress, at least the illusion of progress. Unfortunately, it is during this process that much of the higher level implications of computer-aided technologies on the national industrial base are lost.

One aspect of CALS which has not received the attention it deserves in the United States is that of international cooperation and participation. Many American industrialists are aware of information technology standards in the United States. These are epitomized in Electronic Data Interchange (EDI) commercial standards and various military standards such as MIL-STD-1840A and its family of military specifications. These same industrialists are less aware that compatible and complimentary standards are under review by the International Standards Office (ISO). Or that participation in the international marketplace will depend to a large degree on American industries' ability to conform to these international specifications.

The governments and industrial leaders of both Great Britain and France, to name just two countries, have taken a great interest in the internationalization of CALS standards as a means of access into the American economic system of the next century. With the coming of a united European economy in 1992, the danger exists that without sufficient awareness of international CALS standards, American business access to the European economic system will be hampered. In effect, the communications roadways which are opened by computer-aided technologies might be one-way streets if the United States is not willing to participate now and adapt in the future.

INTRODUCTION

In April of 1987 Under Secretary of Defense Richard DeLauer and Assistant Secretary of Defense Lawrence Korb in a memorandum, pointed out that "the very rapid evolution of Computer Aided Engineering Design and Manufacturing coupled with digital information systems has given rise to an opportunity for major advances in generation, integration, and use of logistic technical information."

This memorandum chartered a joint Department of Defense (DoD)-industry ad hoc group under the auspices of the Institute for Defense Analysis (IDA) to develop a strategy and recommended

a master plan for the development of Computer Aided Logistics Support (CALS) capability. The task force produced early in 1985, a draft report that covered administrative and procedural matters as well as technical issues. The report underwent careful review by the Office of the Secretary of Defense, and in September of 1985, Deputy Secretary of Defense, William H. Taft IV, issued a memorandum outlining a strategy for transitioning from the current paper-intensive weapons system support process to a largely automated and integrated mode of operation with substantial progress to be made by the end of this decade. The stated goal was to have the DoD establish plans to acquire, process and use logistic technical information in digital form for all new weapons systems entering production in 1990 and beyond.

In May of 1986 after much trade association discussion a CALS Industry Steering Group (ISG) was organized under the auspices of National Security Industrial Association (NSIA). The author, then vice president, Strategic Planning, McDonnell Douglas Corporation, was selected as the first chairman of the ISG. The first organizational meeting was held on June 5, 1986 at NSIA Headquarters.

The first Industry-Government joint meeting was held at Hershey, Pa., on July 13-15, 1986 to establish government-industry cooperation. The points of view expressed during this meeting were many and various but began the teamwork which has since exemplified the CALS effort. A formal charter for the ISG was signed on December 15, 1986.

Most of 1987 was spent in pulling together the implementing plans, changing the acronym to include the word acquisition and gaining industry support.

Preliminary discussions of allied country support in a similar initiative were routinely dismissed by industry and government by saying that we had international members on the CALS Standards Group. Also industry expressed concern with sharing our technology overseas.

Attempts were made at this time to involve the acquisition community in CALS policy development, specifically MIL Handbook 59 (a CALS information document for program managers), but participation was very limited, and contracting problems here and overseas were not recognized. The CALS strategy was viewed by many in the acquisition community as strictly a "software problem" and this was aided and abetted by the number of software companies selling "CALS Solution" software.

Deputy Secretary of Defense Taft issued a letter on August 5, 1988 to the service secretaries which became the "main driver for CALS." It directed that systems entering development after September 1988 require proposals for integration of contractor systems and processes, specified government access to contractor-maintained data, and delivery and use of data in standard digital data.

Systems already in full scale development or production will be selected for retrofit based on cost savings, quality improvements from digital delivery or access.

DoD Infrastructure systems will be structured to provide program resources for systems to receive and use digital data, as well as configuring and adapting systems to support CALS standards.

Acquisition policy will be modified to provide further USD(A) guidance as required on contracting, incentives, subcontractors, funding mechanisms.

The International Program

International involvement in the CALS strategy was not considered in the initial implementation plans and the U.S. basically was not aware of the progress of the European and Pacific Rim countries in Computer Aided Design (CAD), Computer Aided Manufacturing (CAM) and Digital Communications. We were still basking in the aura of post World War II that assumed our technology was superior and that allied acceptance of U.S. standards was automatic.

Unfortunately in the beginning CALS was not tied to the 1978 initiative (and still DoD policy) of NATO Rationalization Standardization and Interoperability. We also did not fully recognize the European Community (EC) efforts and what they would mean to international cooperation.

The initial European reaction to the Deputy Secretary of Defense's September 25, 1988 memo which was briefed in draft form to a European audience in London, in March of 1988 was highly negative and the negative reaction emphasized the following points:

- CALS was a U.S. initiative to make it more difficult for Europeans to compete in the U.S. defense and commercial marketplace.
- Europe already had CALS type standards and these had not been considered by the United States.
- The cost of CALS was too great for the budgets of allied countries to afford.
- There were major business and technical issues to be considered before CALS could be implemented in Europe.

It was against that background that the effort to create an international partnership in CALS development commenced in early 1988.

Scope

The remainder of this paper will deal with the efforts to secure cooperation of our European and Pacific Rim allies for the CALS initiative, the initial strategy, the difficulties encountered, the preliminary results and issues. It will present the forward looking strategy and suggestions for the future.

The Initial Strategy

First visits to the UK in March 1988 found very limited support for the U.S. CALS initiative, particularly in the Ministry of Defense. While major UK companies such as British Aerospace, Rolls Royce, and GEC were supportive, there was no single trade association/organization nor government focal point with which the United States could deal. Therefore a definition of a European strategy was undertaken by the Office of the Secretary of Defense with the intent of also applying this strategy in the Pacific Rim countries, if it was reasonably successful in Europe. The strategy proposed was as follows:

"Fundamental changes in the way DoD and U.S. industry are designing, manufacturing, and supporting military systems will impact European defense industries when they market products to the United States, or seek to co-produce U.S. military items.

"There are three basic reasons for urgency in seeking European cooperation for CALS:

1. Interoperability of equipment and support processes substantially required in tactical conflict,

2. Co-production of defense products for U.S. national security and,

3. The economic health of both the United States and European manufacturing industry.

"At present, individuals from Europe participate in the various U.S. CALS groups on a voluntary haphazard basis. As a result, the current information flow is poor, major misunderstandings exist, and initiatives now underway in Europe could result in computer-generated products which are not compatible with the U.S. CALS standards. This would make the problem of interoperability and sustainability in Europe that much more difficult.

"The military necessity for U.S. Forces in Europe to fight side by side with NATO Forces from other countries requires interoperability in all areas of design, supply and maintenance. While it would be economically unwise for the U.S. allies in Europe to forego the benefits of adopting the CALS approach to acquisition and logistic support (inclusive of digital delivery of tech manual and changes thereto), it would be catastrophic if operational readiness for combat was lost due to the inability of allied personnel to use the CALS-based system to repair or support U.S. equipment.

"It is also apparent that the industrial base, including European co-production capacity is required to provide adequate sustainability in the event of localized conflicts which could escalate into a major European war as supplies of spares and spare parts are depleted. Thus, the European defense production base must be CALS compatible to ensure rapid interchange of digital design and producibility data so that production lead time can be cut to a minimum, resupply time substantially shortened, and up-to-date maintenance technical data available in the field.

"The active participation by our European allies in developing and commenting on CALS standards, and participating in the U.S. industry Product Data Exchange Specification effort and other industry/government CALS interface groups would be beneficial, since the infrastructure that substantially aided the U.S. introduction of CALS does not exist in Europe. The understanding of the cost benefits of CALS is not clear to the majority of the governments and military organizations in European countries or their industry leaders. Without a major initiative to promote CALS in Europe, we could find the problem of interoperability and sustainability greatly exacerbated and thereby CALS could actually jeopardize the defense of Europe rather than increasing force readiness as is expected.

"To introduce CALS into Europe successfully and obtain the necessary involvement of the heads of government, military organizations, and industry, a multi-faceted approach is required. The structural situation in Europe is markedly different than in the United States. Although there are multi-national organizations such as NATO, not all U.S. European allies/friends are members. Furthermore, even within the NATO community, divergent national considerations are evident and cannot be overlooked.

"Although there are several multi-national trade and standardization organizations in Europe, there is no single overarching industrial group in Europe comparable to the National Security Industrial Association which has played a key role in supporting the U.S. CALS program through the active participation of its member companies.

"Trade associations in Europe also tend to operate only within national boundaries. Even consortia, established to develop and produce multi-national European military and major commercial systems, have had difficulty in overcoming competing national priorities and concerns.

"A limited number of individuals from particular organizations in individual countries have voluntarily participated in U.S. CALS symposia and have developed some knowledge of CALS, transferring that information to the top or across the broad spectrum of the need-to-know universe within their own organizations and countries ...

"Accordingly, it is essential that a parallel, multi-directional action plan be adopted along the following lines:

- Government to government (political leadership and defense/military organizations)
  - -- NATO governments
  - -- Friendly, non-NATO governments
- Non-government industrial organizations (multi-national and individual country)
  - -- Trade associations
  - -- Technical associations
  - -- Professional societies
- National and International Standardization Groups
  - -- Association Europeene des Constructeurs de Material Aerospatiate, International Standards Organization, European Electronic Association, Society of British Aerospace Contractors, etc.
- Academia
  - -- Universities
  - -- Professional schools
- Individual companies
  - -- Major defense contractors
  - -- Companies co-producing U.S. equipment
  - -- European subsidiaries of U.S. defense companies
  - -- Computer and information processing companies
- Vendors for defense material
  - -- In-country infrastructure

"The actions required to accomplish early and effective European participation in the CALS effort are:

- Policy level contact

  It is essential that the policy level managers of the U.S. Government regularly and routinely introduce the importance of CALS into meetings with their policy level counterparts and seek designation of key points of contact for CALS in each country. Particularly the Department of Defense, but also the Department of Commerce and Department of State should be involved in this activity. A letter from the Secretary of Defense level should be transmitted to each European counterpart at the earliest opportunity.

- Military interface

  The U.S. military leadership should take every opportunity, whether through formal NATO

organization activity or as a result of direct dealings with their counterparts to stress the importance of CALS to mutual defense considerations and advocate participation in the CALS program. CALS concepts, policies, and program information should be incorporated into military service school curricula (NATO PM course and NATO War College).

- Seminars and symposia in Europe

  It is standard practice for the U.S. to invite the European community to CALS sessions in the United States (Department of Defense, National Institute of Standards and Technology, National Security Industrial Association, American Defense Preparedness Association, Society of Logistics Engineers, etc.). However, a broader audience can only be attracted if there are well prepared and well publicized CALS sessions in Europe that are tailored for the intended audience.

- Information flow

  The transfer of CALS material to Europe, whether it is general descriptive literature, or official documents such as U.S. policy directives and standards, has been sporadic and limited. Very often the printed material presumes familiarity with the information as a result of previous knowledge or participation, and thereby is not useful even for the limited audience in Europe that it now reaches.

- Standardization organizations

  There are international organizations with U.S. and European membership. Full advantage of their existence has not been taken for CALS standards, even though there are some practical limitations to the role they may play due to their specialized nature and open membership.

- Country-by-country liaison

  Recognizing the diversity of the European community, the United States must undertake a program of introducing CALS into each country, at the same time that it is promoting CALS on a multi-national basis. This should be accomplished by teams of two to three knowledgeable people having one-on-one meetings with key government, industry and trade associations, officials, similar to the recent liaison visit to the U.K. by a representative of OSD."/ 1

IMPLEMENTATION AND ISSUES

To implement the above strategy, visits were made throughout Europe and the Pacific Rim. In Europe a major effort was made to secure NATO cooperation while in the Pacific Rim the efforts were limited to informational briefings. The briefings conducted were of a policy and information nature with the interest of insuring understanding of the U.S. CALS initiative.

It quickly became apparent that the approach used to organize the CALS strategy in the U.S., i.e., single government and industry steering groups would not be effective overseas as demonstrated by the following differences.

1. The U.S. has strong trade associations that speak for industry. While European/Pacific Rim countries

have many associations, none speak for companies or industry.

2. The U.S. has strong infrastructure versus weak infrastructure in the Europe/Pacific Rim countries.

3. The U.S. has centralized acquisition policy (Federal Acquisition Regulations/Defense Acquisition Regulations) while European/Pacific Rim countries have a variety of acquisition policies, procedures and practices.

4. The U.S. has a strong defense industry while primarily commercial companies are involved in European/Pacific Rim countries' defense industry.

5. The U.S. has a single legal system versus a variety of legal systems in European/Pacific Rim countries.

6. The U.S. has no language barrier. Language is a significant barrier in European/Pacific Rim countries.

7. CALS-EDI have been separate efforts in the U.S. while EDI includes CALS in European/Pacific Rim countries.

Thus the strategic approach in each country had to be tailored. Most importantly the cultural differences had to be considered. The discussions in the U.K. and France were most fruitful, however, a number of countries are waiting for the results of the NATO Industrial Advisory Group CALS study being conducted for the NATO Conference of National Armament Directors (CNAD).

The most significant error in the strategy was the lack of recognition of the great pr gress that had been made, most particularly in Europe and Japan in digital communications. In Europe, CALS type strategies fall under the umbrella of Electronic Data Exchange (EDI). The European Fighter Programs (EFA) incorporate significant integrated digital systems for Intergrated Logistic Support (ILS) and is defined in Association Europeene des Constructeurs de Material Aerospatiate (AECMA) specifications 2000m and 1000d.

U.S. industry has been slow to recognize the advances made in CALS type strategies by such companies as GEC (UK), Rolls Royce (UK), Aerospatiale (France), MBB (Germany), FFV (Sweden), Mitsubishi (Japan), Hyundai (Korea) and many others. Little attention has been paid to the work of a European Community industry consortium called Esprit and the industry digital architecture program CIMOSA. The French are far advanced in their shipyards in digital automation and the provisioning systems used in specifications AECMA 2000m and 1000D are considered by a number of logistics experts to be superior to those in U.S. MIL-STD 1388 and its successor MIL-STD 13882B.

It was not until January 1989 that the International Committee of the Industry CALS Steering Group was organized. It has been primarily engaged in organizational matters, marketing and liaison with the AECMA which represents only a small part of the European Industrial community and is limited to aerospace. The efforts from this group if directed toward international U.S. companies could be significant.

The approach by the Office of the Secretary of Defense (OSD) in concentrating the efforts in country informational visits and emphasizing

the need for a CALS strategy within NATO and most particularly at the NATO Maintenance and Supply Agency (NAMSA) has paid off handsomely. As a result the U.S. policy on international activities was clarified in March of 1990 as follows:

> The basic objectives are twofold
>
> -- DOD CALS interoperability with our allies,
>
> -- Efficient digital interchange with the international supplier base.
>
> This requires the following actions:
>
> -- Standards - Use international standards. Build translations where needed. Emphasize cooperative development of new standards.
>
> -- Technology - Bilateral or multilateral agreements in areas of mutual benefit.
>
> -- Acquisition - Provide CALS requirement in international contracts. Encourage U.S. prime contractors to make cost effective arrangements with international suppliers for integration, online access, digital delivery.
>
> -- Infrastructure - Coordinate with allies on CALS user delivery systems needed for near-paperless operation and support.

The implications of the policy are clear. DoD contracts will reflect CALS requirements. There will be phased implementation with strong U.S. industry support. CALS requirements will be specified for cooperative production, second sources, subcontracting for both multi-national development and operations. The resulting digital data will be based on international standards, resulting in improved quality, productivity, readiness, and sustainability.

Although there is not complete acceptance of the CALS initiative, the need for international cooperation is well recognized in Europe and the Pacific Rim and, given the slow start, much has been accomplished. Accomplishments in the 1989 and 1990 time frame include: CALS offices in Canada, and France have been established, Points Of Contact in NATO countries, and Australia are in being, bilateral data exchange agreement with France has been executed, European industry CALS studies (NIAG, AECMA) are ongoing, NATO/CNAD AC-301 responsibility for CALS established, and briefings and visits made to Pacific Rim nations (Japan, Singapore, Korea and Australia). U.S. CALS industry steering group -- International Committee organized in January 1989, CALS Europe '90 Expo in Brussels, November 1990. CALS "Australia" '91 is scheduled in Sidney June 25-27, 1991 and CALS Europe '91 at the Haig, Netherlands, October 9-11, 1991.

International issues as yet unresolved are being addressed and each one represents an awesome challenge for the acquisition community. Many of these issues also face the U.S. government/industry domestic acquisition community in a lesser degree.

The technical issues are (1) a definition of standards and conformance tests. How do we do it? Who does it? Who certifies conformance? (2) Standards for translators and bridges among various standards; and (3) How will data protection and security be provided?

Unresolved business questions include: (1) Data Rights, a major issue in the European Community; (2) Intellectual property rights; (3) Subcontract flowdown, how to be managed; (4)

Delivery, verification, acceptance procedures for data; (5) Training for CALS implementation. Who does it? What is content? (6) Costs for transportation or data transmissions. (7) Requirements for major cost accounting (benefit determination) changes; (8) Business cultural changes for total quality management.

The Forward Look

Because of the complexity of the issues facing NATO in dealing with 13 nations on CALS issues, the United Kingdom National Armament Director to NATO recommended that a four power CALS committee, consisting of representatives of the U.S., U.K., France and Federal Republic of Germany be created to deal more rapidly with International CALS issues. This group has met twice, most recently in December of 1990. From the group it is believed will come the *forward strategy* with NATO setting the overall policy and the four power group providing joint technology development and exchange, and implementation procedures. At this time it is believed the European countries accept the ISO/MIL-STDs currently existing for CALS providing they consider AECMA 2000 and 1000D.

The next step however and that is a very difficult one, is the internationalizing of the development of the U.S. Product Data Exchange Standard (PDES) through the ISO European Standard to Exchange Product Data (STEP) These may be defined as follows:

The Standard for the Exchange of Product Model Data (STEP) is a neutral mechanism capable of completely representing product data throughout the life cycle of a product. The completeness of this representation makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing databases and archiving. /2

Product Data Exchange using STEP (PDES) is the U.S. organizational activity that supports the development and implementation of STEP. It will act to ensure that the requirements of U.S. industry are incorporated into STEP. It will provide U.S. industry with a methodology for the implementation of STEP standards. /3

The effort is extremely important to industry and government, domestically and overseas. To industry, it offers survival. Digital links with suppliers and customers are a necessity to be competitive in late 1990's. It affects small business as well. And it enhances productivity of all. Digital product data exchange (both internal and external) shortens cycle times, reduces costs, improves quality.

To DoD and MoDs and other buying agencies, it offers some help with the issue of budget constraints. PDES-driven technology enables us to do more with less:

-- Concurrent Engineering (30-40 percent savings in time and money)

-- Automated manufacturing (e.g., spare parts on demand)

"High Tech" products and systems like the B-2 bomber, EFA, Advanced Avionics require integrated design and manufacturing, multi-enterprise networks. Without PDES, we must keep inventing custom solutions.

CONCLUSION

As CALS is advanced by PDES through STEP, the far reaching effects on the domestic and international industrial base is readily apparent. If we look to 1995 and beyond we project wide scale industrial networks,

distributed data base technology, paperless procurement systems, just-in-time data for product support. PDES/STEP-driven manufacturing, process improvements through functional integration.

However, to make this system work there must be a sense of urgency on the part of U.S. industry. With the initiation of the European Community in 1992, we will no longer have the freedom to negotiate with individual countries in Europe. The tremendous change taking place in Europe, the collaboration in technology development between European and Pacific Rim countries, the fierce global competitive forces, demand from U.S. industry a strong effort to improve productivity so at the minimum, a level playing field exists if not a very real competitive advantage. We are at a very real crossroads in international competition and CALS offers to the acquisition community in both commercial and defense industry an outstanding strategy to improve our global competitiveness. Thus we must accelerate our efforts to reach agreement with our allies in the European arena as well as the Pacific Rim on Digital Data Exchange Standards. We must resolve the issues previously discussed, promptly, a task for the acquisition community and lastly accelerate the implementation of PDES through STEP to maximize its benefit.

With CALS strategy implemented, and hopefully a national initiative which joins the defense industry with the commercial industry in CALS initiatives we can regain our economic health and be the most productive and globally competitive nation in the world.

ENDNOTES

/1 Freeman-Griner Report to OSD, CALS office April 1988.

/2 ISO document "STEP Part 1: Overview and Fundamental Principles."

/3 IPO Steering Committee, March 1990.

MODULAR WEAPONS SYSTEMS PROGRAM (MSOW)

A U.S.- System Program Manager's Perspective

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AF Wright Laboratory

ABSTRACT

The Modular Standoff Weapons Program was an international cooperative development program involving originally seven nations: Canada, France, Germany, Italy, Spain, United Kingdom and USA. During the course of negotiations, France and Canada withdrew from the program. Even though, or maybe because of, it was agreed to use US procedures with minor modifications as spelled out in the respective MOUs. Each nation had to forego its usual way of doing business, which resulted in many interesting situations. . The problems (many of which originated in the different cultures involved) we experienced in attempting to set up this multi-national cooperative program and the lessons learned are highlighted. A brief historical background and description of the MSOW program is provided.

The MSOW management structure is discussed and with it the national approval process for funding, which is quite different among the participating nations. Issues involving US & acquisition process which required FAR waivers, shared costs, bombing arrangements, scheduling and technical requirements are discussed.

The advantages as well as disadvantages of an international cooperative program are discussed with respect to cost. We also looked into the technical merits of the international program and related problems that appear throughout the program development, starting with the Statement of Work until cancellation of the MSOW program.

The author's view is presented on why the MSOW program failed. The presentation concludes with some recommendations for the execution of a successful international program.

INTRODUCTION

The Modular Standoff Weapons Program was an international cooperative development program involving originally seven nations: Canada, France, Germany, Italy, Spain, United Kingdom and USA. During the course of negotiations, France and Canada withdrew from the program. It was agreed to use US acquisition procedures with minor modifications as spelled out in the respective Memorandum of Understandings (MOUs). Each nation had to forego its usual way of doing business, which resulted in many interesting situations. All partners were equal but the cultures involved were quite different. We encountered numerous challenging problems during the execution of the program. The purpose of this presentation then is to provide information on key issues of the program, so that future international cooperative programs can benefit from it. The lessons learned and the views expressed here are those of the author and do not reflect the official policy of the Aeronautical Systems Division, the Air Force Development Test Center, Air Force Systems Command, or the US Air Force.

It may be appropriate at this time to distinguish between the US-SPO functions and that of the International Program Office (IPO). In general terms the US-SPO was to look after the US interests while the IPO was to execute the program as agreed to by all participating nations. A more detailed discussion of the MSOW management structure will follow. The lessons learned from the IPO's point of view, as well as the perspective of the international program director, can be obtained from the Director of the DSMC Multi-national Program Management Course. For better understanding of the events and the issues that eventually led to the cancellation of the MSOW program, we need to go back to the history of the MSOW program.

BACKGROUND

Program Description. The Modular Standoff Weapons program is a multi-national development program between the United States, Federal Republic of Germany, United Kingdom, Spain and Italy. The project definition phase (Dem/Val) is designed to reduce risk for the following FSD phase. The MSOW system is an aircraft launched, conventional munitions carrier with three variants.

Variant A is a short range weapon to go after fixed high value targets.

Variant B is the same weapon as A, but with extended (long) range capability.

Variant C is a short range weapon against mobile high value targets.

As shown in Figure 1, the different variants are composed of the same modules, e.g., variant A and B may have the same guidance, airframe and engine modules, but differ in fuel tank and payload (hence modular standoff weapon). All vehicles would have navigation-guidance systems on board to achieve the necessary accuracies. Appropriate munition (submunition or unitary warhead) will be carried depending on the target set to be defeated (runways or bunkers). These weapons will be interoperable on a number of NATO aircraft. MSOW variants weight classes are 700, 1000, and 1600 kg.

At this juncture I would like to point out that there has been a lot of discussions between the nations. The main US aircraft being the F-16 could only carry the 1000 kg version, however, the UK and Germans aircraft (Tornado) could easily carry the 1600 kg versions, which by the virtue of carrying more submunition was considered to be more cost effective. Both groups insisted on having it their way. Finally, the US proposed a modular system as a compromise, which was accepted by all participants. The US later changed its mind on that.

CONTRACT

It was agreed among the nations to use the US contracting procedures. Each nation was expected to waive or deviate from its national procedure where they conflicted with the MOU. The US had a large number of waivers and deviations to the Federal Acquisition Regulation (FAR), and the discussions on when the FAR would apply or not were very lengthy and difficult. However, the deviations and waivers are too numerous to mention here. See separate paper in the proceedings entitled, "The Modular Stand-Off Weapon, Federal Acquisition Regulation Waivers and Deviations in an International Acquisition." The lesson learned here is that the US acquisition process is by far too rigid and inflexible to allow it to be applied to international programs.

It has become obvious that the Europeans do business quite differently from us. Their source selection is much less regulated and provides them more freedom

than the FAR. It was agreed to use a fixed price contract which required special authority from the Under Secretary of defense for Acquisition, as the development contract was in excess of $10M. In comparison, the UK and Germans made every effort to achieve fixed price contracts.

History of the MSOW Program.

1984 Multi-national Long Range Standoff Missile (LRSOM) and Low Cost Powered Dispenser (LOCPOD) studies were initiated. Studied indicated that standoff systems are survivable and cost effective for the missions studied and further pursuit of standoff weapons was warranted.

Jan 1986 The seven nations began discussions and formulating the MSOW program. During the same time, the "Nunn Initiative," made money for internal programs available. This fund, outside the regular AF budget, encouraged certain US officials to support the MSOW program without user involvement.

Jul 1987 Memorandum of Understanding (MOU): The General Memorandum of Understanding for Collaborative Development and Production of a Modular Standoff Weapon System was signed by Canada, France, Federal Republic of Germany, Italy, Spain, United Kingdom, and the United States. It spelled out the general rules and committed no money. The program was to start with Project Definition Phase (NATO term for US Dem/Val). Every phase of the program required a supplement MOU which would be negotiated separately. It included a financial annex.

Sep 1987 MSOW Request for Proposal (RFP) was released to the international public. We had hoped to have two contractors, but could afford only one.

Mar 1988 Responses to the MSOW RFP were received.

May 1988 France withdrew from the MSOW program.

Jun 1988 Canada withdrew from the MSOW program. France and Canada withdrew over some cost/work share issues and third country sales of MSOW weapons issues.

Aug 1988 MSOW RFP amended due to the withdrawal of France and Canada. New cost/work shares were determined and specified in this amendment.

Feb 1989 The issue 1000kg vs. 1600 kg weight class resurfaced again, although at onset of program it was agreed that modularity was going to resolve that problem.

Jun 1989 Source selection evaluation completed.

Sep 1989 United States and United Kingdom withdrew.

Dec 1989 US MSOW national program office disbanded

Dec 1989 Final direction to IPO from remaining three participants.

Jan 1990 IPO closed.

Management Structure.

Figure 2 depicts the MSOW management structure. The Armament Directors, Deputy Secretary of Defense level, got only involved when issues could not be resolved at the Steering Committee level. For instance, when US and France could not reach an agreement on cost/work share and third party sales, the issue was elevated to the Armament Directors. It led eventually to France withdrawing from the program.

The letter announcing the US withdrawing from the program was also signed by the Deputy Secretary of Defense.

The next management level is the Steering Committee, which represents the next highest level MSOW management level to which a program conflict or issue can be elevated for resolution. Each participant appointed one Steering Committee member. Members of the committee were general officers or civilians equivalents. Note that the European members were at MOD levels whereas the US member was Air Force HQ (SAF/AQ) level. All committee decisions were unanimous and disagreements within the committee were to be resolved by consultation amongst the participants without recourse to outside jurisdiction. Issues that could not be resolved at the Steering Committee level, were elevated to the national Armament Directors.

Management Group. The Management Group is responsible to the Steering Committee for coordination amongst the participating nations. This group is composed of one representative from each nation. The national representative is also the national program manager, with the exception of the US. We did things differently. At that level the US had three offices involved. One at HQ Air Force (SAF/AQPT), one at AFSC HQ (XTW), and one at Eglin AFB Base, Florida, the US- National System Program Office (US-SPO). This represented a bureaucratic nightmare, not to speak of the overhead involved.

The management group planned the various phases of the program with all the necessary actions. The group tasked the International Program Office (IPO) and planned for subsequent phases of the program. The group also resolved issues referred to it by the IPO and worked those tasks delegated to it by the Steering Committee. All group decisions were to be unanimous and all disagreements were to be referred to the Steering Committee for resolution.

Internal Program Office (IPO). The IPO was responsible to the Management Group for the day-to-day planning and execution of the program. Each participating nation was to contribute personnel (five to seven personnel from the US, UK, FRG, Canada, and Italy, and three to five personnel from Spain) to support the IPO. All members of the IPO took their instructions only from the IPO program manager who served impartially on joint interests of all the participants. Issues likely to significantly affect the program, as determined by the IPO, were referred to the Management Group for its decision and direction. Participants were to have equal right of access to all program information.

National Program Managers. These Program Managers were spokesmen for their nations.

International Cooperative Development Efforts.

First let us discuss source of the ADVANTAGES of international cooperative efforts. With the advent of "high tech" and its introduction into weapon systems, worldwide development and procurement of next generation weapons have increasingly become more expensive. In an effort to meet these costs, various nations, especially European NATO members, called for greater international cooperation in the procurement of sophisticated and expensive weaponry. There is no doubt that international cooperative efforts have many benefits not only cost sharing but also political, as well as operational, e.g., in Europe interoperability and commonality. To attach dollar values to these benefits is not possible in this context. The benefits of a cooperative international effort set aside for the time being, we know the total

cost of a system development, in this instance, MSOW went up for many reasons, some of which will be listed in the following. However, the cost share per individual national can be kept lower than the cost of developing the system nationally. Figure 3 tries to illustrate the cost growth of the program as a function of the number of nations participating.

It is extremely difficult to accurately assess the program cost increase due to adding new participants to the program.

However, based on past experiences and discussions with people involved in international cooperative programs, the following assumptions were made: Cost increases vary from 20-30 percent per added nation (K+K(N-1)A% where "K" is program cost, "N" is number of nations, and "A" is percent of cost increase. Using an exponential function like ^{3}N as a cost increase factor (suggested by some) yielded comparable results.

As one can see in Figure 3, there is a practical as well as economical limit to the number of partners in cooperative efforts. Figure 3 would suggest that more than 5 participating nations would not have any financial benefit. A case in point is that the individual national cost of MSOW program did not significantly change when the seven nations (US, UK, FRG, Canada, France, Italy and Spain) participating in the program shrank to five, with France and Canada withdrawing from the program. The ideal situation would be a two or three nation partnership.

Now let us consider some of the factors in international cooperative development programs that contribute to increased costs.

As participating nations have differing national requirements, there is a need to consolidate the requirements which will result in a lengthy negotiations which lead into extended procurement time. A good example is the difference in requirements between US and some European countries on 1000 kg versus 1600 kg MSOW variants. Much time has been spent until agreement was reached, which really was a compromise. In this case, we were to build a modular system as proposed by the US. Of course this meant increased cost and decreased performance. Another example is guidance. US insisted on GPS being part of it and the Europeans wanted some terrain following system as they felt they would not have access to GPS when they needed it. So another compromise was reached. MSOW will have both on board. Bottom line is that different national requirements call for compromises with cost increases. The end products may have more performance requirements than each individual nation really wants.

Another contributor to the increased cost is the cost of work share arrangement. Each participant pays an agreed cost share and expects work in return to be comparable to its cost share. This may dictate for arrangements that are not always cost effective, e.g., a nation may be doing work based on work share arrangements that another could do more cost effectively.

Now let us discuss some of the facts of the program that would DISCOURAGE international cooperative programs. Some examples are:

The complex management structure will encompass delays and increase cost. See MSOW Management Structure.

The already lengthy procurement process will be considerably lengthened.

Satisfying many national requirements may lead to compromise of own national requirements and could increase the cost of the end product, but the total number of buys will go up, which could keep price

down. Because of cost/work share consideration, there may be limitation to competition.

At this point I would like to ponder on one particular aspect of the MSOW program, user support. That is the one I believe contributed most to MSOW's demise. The user never supported the MSOW program as evidenced in a HQ TAC message that stated the tactical Air Force believed they could satisfy their standoff weapon requirements with existing weapon programs. From the early stages of conception and planning, the user has never been involved.

The lesson learned here is that of all considerations for entering into an international cooperative program, the one that addresses and satisfies the national defense policy and requirements should have overriding priority. Make sure the user is on board, and all other concurrent national programs are also considered.

International programs should only be considered as an economical option after it has been established that the national requirements, cost and risk reduction criteria have been met.

Having said this begs the question,

<u>Why Has the USAF Joined the MSOW Program?</u>

I can speculate on the events (also see History). Intelligence and NATO studied have led to the establishment of the NATO threat and target documents. Analyses indicated that standoff weapons are the most cost effective way to defeat these targets. Many national efforts were underway and politicians called for cooperative efforts to share in development costs. The Senator Nunn initiative encouraged and set funding aside for international efforts. Such efforts would also help in developing commonality and interoperability of weapons, etc. In short, the time and stage seemed to be right for joining the MSOW program. At OSD and AF headquarters, decision was made for the US to participate in the MSOW program. Chief of Staff, General Welch, announced Air Force support of MSOW, while TAC went on record as not supporting MSOW. TAC also reasoned international programs take too long and do not deliver what TAC really wants.

Obviously there was no unity within the Air Force and no nationally coordinated plan involving user and national defense policy. An OSD Joint Conventional Standoff Weapon Master Plan was established later under pressure from Congress. It is unclear whether all Air Force programs that play in the overall defense strategy were considered.

Now since the Air Force has joined the MSOW program for one or another reason, I will discuss in the following paragraph some MSOW concerns and derive some lessons learned.

<u>MSOW CONCERNS</u>:

<u>Program Management Concerns</u>. Although, the other participating nation's program managers had full responsibility and authority to speak for their respective country, this was not the case for the US. The US input was injected through three USAF spokespersons: SAF/AQPT, chairman of the Management Group, AFSC/XTW, and MSD/YGX, which was the US-national program manager. This was a bureaucratic and administrative nightmare. The US program manager worked in this "triad" structure by caucusing before each Management Group meeting for the purpose of presenting a single USAF position. AT this point, no user (TAC, SAC) involvement. However, HQ AF told me that user requirements

would come from SAF/AQPT. The MSD/YGX program manager had essentially an "observer" role at the international meetings. This did not match the responsibility and authority of the counterpart national program managers.

Efforts by the US program manager to get the user involved were negated by AF Headquarters.

Actions of the Management Group could only be taken or passed on to the IPO upon unanimous consent, which required true cooperation among the nations. Sometimes issues needed to be elevated to the Steering Committee, which required time, causing delays in the program.

Recommendation. The overall management structure with unanimous decision forces a true cooperation among the nations, however, at expense of time and cost. For sake of efficiency and time savings, conflicts need to be resolved at working levels as much as possible. The Steering Committee was called only twice to resolve issues. Obviously the US- "triad" structure didn't work too well, as it is contrary to sound management principles. The US national program manager needed to have the authority to go with the responsibilities to do the job, i.e., same arrangements as with any national system program office. Also give him the freedom to do whatever needs to be done, e.g., to pull in user support.

There was no continuity of program management from program inception to execution, which created confusion. Program managers should be appointed as early as possible and kept on the program as long as possible. Also, user support needs to be pulled in as early as possible.

Another management concern that could have impacted severely on the program schedule was the different national approval process for funding. Each nation has a different approval cycle and mechanism. In the US the budget for any program gets approved yearly (budget cycle), in contrast to European nations where the total budget for a program gets approved, and the expenditure of the money for each phase needs approval again, but is independent from fiscal year cycle. Once the money is approved, it may take between one to four months before it is actually available, which required creative financing and good faith cooperation between the nations in order to avoid further delays in the program execution. Remember we cannot sign the contract if the money is not in the bank.

The money approval process itself varies with the nations and can take several months, since Parliament approval is involved. It also required knowledge of the actual cost. However, the contractor has not been selected yet. Here innovative management was called for to make the program executable and minimize delays. We also had a team of international bank experts meeting for quite some time to work out all the banking arrangements.

Acquisition Process Concerns.

It was agreed to acquire the MSOW system using the US acquisition process. This required lots of waivers and deviations, because of participants' national laws and regulations, which needed to be negotiated and approved. Without going into any detail, my conclusion is that the Federal Acquisition Regulation (FAR) is too rigid and inflexible to really accommodate international programs. Details of the MSOW acquisition process will be discussed elsewhere.

Recommendation here would be to develop new or amend existing FAR to better accommodate international programs.

Joint Requirement Concerns. The requirement for weight class emerged very early in the program discussions among the nations. The European participants wanted mainly the heavy weight MSOW class (1600 kg) as their main carrier (Tornado) can carry four of them and their analysis showed the heavier version to be more cost effective. However, the US plans called for F-16 as carrier, which can carry only two 1000 kg MSOW variant. The solution was found in the modularity approach which the US introduced and everyone seemed to be happy with. There were also differences between the nations in the required standoff ranges. The UK wanted somewhat more extended ranges than the rest of the participants. Technically this would not create any problem as with the perceived MSOW design cost for additional range would equate only to cost for fuel (within given limits of course). Initial discussions with participants indicated, especially with PD phase demonstrating the MSOW feasibility on a 1000 kg variant -A/B, that the difference could be overcome. Later on the US disregarded the modularity concept and attempted to persuade the other nations to accept the 1000 kg short range variant only. The US argued that they never had a requirement for 1600 kg variant. However, this had not been conveyed to the other participants in early negotiations.

Recommendation. Once agreement is reached, do not change and/or add additional requirements. It will lead to delays and, in the case of MSOW, to program cancellation. Interesting observation: At program onset, modularity was introduced by the US as a solution to differing requirements which was accepted by the other nations and the US signed up to the program. Later the same difference in requirements was cited as reason to pull out of the program (letter of 6 Sep 89 signed by Deputy Secretary of Defense Atwood).

Cost Work Share Concerns. Each nation's objective was to field a system to meet its military requirement. However, national "business" objectives of the nations wanting to get a return on their investment were prevalent. This has developed into a major issue between France, Canada and the US and contributed to France and Canada to withdraw from the program. Specifically, work share equivalents among the nations were negotiated. As a result of this, one nation was given an area of responsibility where another nation already had the expertise. This could add to the cost of accomplishing the task as well as to the time to accomplish the task.

Recommendation. Tolerate some imbalance in cost/work share and find equitable ways to make up for the deficit. Another way could be to readjust the cost share once a cost effective work share has been established.

Cost Estimate Concerns.

In the early planning stage of MSOW, the US government estimated the cost based on a conventional MSOW design, which was supposed to give an order of magnitude dollar estimate. As planning continued and each nation's operational requirements were incorporated into a consolidated requirements document, the concept became more firm. These requirements were forwarded to industry for industry's opinion as to the feasibility and for a rough order of magnitude cost estimate. The costs that came in were way above initial projections. These initial (US government) projections gave the nations a false perception as to what the MSOW would cost.

The various requirements of each national that contributed to the requirements list also added to inaccurate estimates of the MSOW

program cost. The bottom line result was that requirements were downscoped at the expense of a delay to the program.

Recommendation. Cost estimates must be based on realistic requirements. The requirements should be technologically as well as operationally sound and must be coordinated by the user. Other nations support of programs and future of programs depend largely on credible cost estimates. We have little experience in estimating international program cost, which is a reason for grossly over or underestimating cost. However, we need to avoid the action or even creating the perception of selling the program low with the intent of buying high later in the program.

Technology Transfer Among Nations.

As discussed earlier in this paper, there are many reasons for internal cooperative development programs. One that has not been discussed thus far is gaining access to certain technologies that may rest with one or another nation. We must be sensitive to the fact that there are many considerations involved such as proprietary rights, national laws, national security, etc., that may restrict or even prohibit some technology transfer.

Recommendation. The problem of technology transfer must be addressed very early in the negotiations. Full understanding must be reached on what can and cannot be exchanged. Technologies that are being developed during the program become property of all participating nations of course. However, some of the evolving technology during the program may be based on "restricted" technology. This creates problems and questions that need resolution before program execution. Bottom line here is that full understanding of the technology transfer problems and agreement must be in place before contract is signed. Once agreement has been reached transfer should be flowing freely.

User Support.

Last, but by no means least, a few words are in order about user support. As in national programs, user support is also essential in international programs. The AFSC was directed to support the MSOW program in the USAF PMD 7256 (1)/64248F, the Modular Standoff Weapon Program, dated 16 Jun 87. US user support was perceived to be coming via an endorsement/concurrence on requirements spelled out in the NATO Staff Requirement (NSR) AC/224-D/760, dated 23 Jun 87. In the PMD, TAC and SAC were directed to provide inputs to areas as testing, advise on critical issues, maintenance concept, and concept of operation for mission planning.

It is this program manager's perception that the user was left out of the SAF/AQPT, AFSC/XTW and YGX chain. The MSD/YGX program manager was given direction that user input would be at the SAF/AQPT level, furthermore, the PMD directed user participation.

Early in the program, TAC formally withdrew its support from the MSOW program in a HQ TAC message which stated the Tactical Air Force believed they could satisfy their standoff weapon requirements with existing weapon programs.

Recommendation. It is paramount to any weapons acquisition program that the user is brought on board very early in the program and their requirements must be fully addressed. The user must be made a full partner of the acquisition team. The program manager must have authority to engage the user in the program whenever he deems it necessary.

Summary.

Based on the two years experience as the MSOW US-SPO manager, I have drawn up the following list of recommendations that may improve the chances for international cooperative development programs to succeed. They are also applicable to national acquisition programs of course.

- The current US acquisition process (FAR) needs to be amended, changed or even rewritten to make the rules more flexible to accommodate international acquisition programs.

- The management structure should be more streamlined, especially the US side, to eliminate unnecessary overhead. Although cumbersome, in general during the two years of existence, it was workable, especially if issues were resolved at working level as much as possible. However, the US program manager needs to have authority commensurate with his responsibilities. He makes program decisions for his nation.

- Be aware of and understand the national peculiarities of the partners, e.g., the time line involved in their budget approval process. Recognize the fact that they do business different from the US. Realize that we are dealing with different cultures.

- Advanced detailed planning (from cradle to grave) of program is necessary with user inputs. Keep same personnel involved whenever possible.

- Program must be assembled based on national (user) needs and national defense policy. Commonality (NATO) and interoperability, politics, eventual cost savings, etc., may be considerations but not deciding factors.

- Assure that all essential US requirements are met.

- Once plans and requirements are well established and accepted by user and in consonance with national defense policy, obtain realistic cost estimates.

- Look at economics of cooperative program after all national goals are satisfied.

- Base cost estimates on realistic and firm requirements. Don't create perception to sell low and buy high.

- Agree to and stay with acquisition strategy.

- When establishing cost/work share, allow flexibility and tolerate some imbalance up to 10 percent.

- In order to maintain schedule, do not allow redefinitions, amendments and changes in requirements to take place.

- Technology transfer. Be aware of national laws, etc., and settle all rights before program initiation. During program execution, all transfer must be free flowing.

- Keep user involved from program start until completion.

- At this time I would;d like to add one recommendation which was not discussed previously but I feel is very important. It is:

Act in good faith and be honest with partners about motives and goals of the program. When the US withdrew from the program, simultaneously with the UK (both countries had worked out separate deals excluding Germany, Italy, and Spain), the remaining partners felt deceived. The MOU requires consultation with partners before one partner withdraws from the program.

Finally I want to address the question,

Why Did the US Withdraw?

That decision was made at the highest level at the Pentagon. The official letter announcing US withdrawing from the program states differing national requirements. The US letter signed by Deputy Secretary of Defense D.J. Atwood Jr. reads in part as follows: "...We have decided that we cannot continue to support the MSOW system programme because we believe that the differing national requirements would be difficult to reconcile even with a modular programme..." These differing national requirements were addressed in the early discussions and negotiations among the nations and overcome via modularity concepts when the MOU was signed.

It is obvious that MSOW did not meet some of the essential ingredients for a successful international program, and therefore was prone to failure. At the conception of the program, there was no detailed overall encompassing standoff weapon plan that covered all aspects of development and testing, and procurement. User participation was notably not only absent from the onset of the program, but the user went on record that he did not have a requirement for MSOW.

MANPOWER, PERSONNEL, and TRAINING

ACQUISITION WORK FORCE

COMPETITIVE CONTRACTING OFFICES: IMPLEMENTATION ISSUES

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ABSTRACT

The concept of competitive contracting offices (CCOs) initially was proposed in a research paper presented at the 1989 NCMA/DSMC Acquisition Research Symposium. This paper reports on the opinions of the acquisition community expressed about that proposal.

Under the CCO concept, project officers and other customers would choose whichever contracting office they thought would best fit their needs. The customer would pay for the contracting services; the contracting office would not be funded by other means. As a result, those contracting offices providing a high level of customer satisfaction and creating a loyal customer base would continue to thrive (using revised compensation practices for personnel), while those not doing so would go out of business.

Government and industry acquisition policy makers and practitioners were canvassed to elicit their opinions on the CCO concept. The results were extraordinary. Most believed that with the concept the temptation to violate laws, regulations, and good business practice was too great for contracting personnel to resist. Our respondents believed that contracting personnel are not strong enough to resist the temptation to reap personal gain by satisfying the customer at the expense of regulatory and legal compliance. Because an important feature of the CCO concept is to provide strong compensation rewards to the most successful managers and employees, many believe that a combination of lack of integrity and pressure to succeed will pervade the organization and lead to serious abuses.

Other impediments to implementing the concept have been mentioned by various reviewers. These include a nonresponsive civil service system, the fact that private companies do not employ the concept, increased difficulty in meeting socioeconomic goals, and lack of a well-trained work force. But we are of the opinion that all of these objections can be readily overcome.

Most reviewers think that use of the proposed personnel reward system would result in greater customer satisfaction. Some of the more adventuresome have warmly embraced all of the general features of the proposal. Others think that the basic concept has merit but that additional study is needed, or that the culture shock would be too great for the concept to achieve executive-level support.

The concept provides for certain controls to deter or, if deterrence fails, detect criminal behavior. However, many thought that those controls would not be effective. Until the general perception of lack of integrity no longer exists, implementation cannot go forward, nor can much else in the way of procurement reforms.

Competition within government should be implemented where it makes sense; we are continually reminded by the free market that competition "obligates every man to endeavor to execute his work with a certain degree of exactness,

. . . and frequently occasions the very greatest exertions." (Adam Smith, 1776)

INTRODUCTION

Customers commonly claim that they are poorly served by their contracting organizations. Complaints include claims that contracting takes too long and is too unwieldy and that practitioners are neophytes or poorly trained. In response to such complaints about the contracting systems and a recognition that changes are required, many proposals have been made. These include simplifying Departmental regulations, giving the job professional status, establishing a single civilian acquisition corps, and proposals to avoid congressional micromanagement.

We feel that most of these proposals fail to address the root causes directly, that they tend to treat the symptoms only, not the disease – a monopolistic bureaucracy. Therefore, we sought to apply commonly accepted economic theory and practice to the operation of contracting offices. The result is the concept of CCOs, under which customers (1) are allowed to choose the office that best serves their needs and (2) pay for the services received. We believe that using this approach will reap the benefits of competition – specifically, more responsive service to customers – as well as providing the level of cost, timeliness, and quality that the customer requires. At the same time, control systems can be put into place to ensure that laws, regulations, and good business practices are followed and that abuses are detected. To provide financial incentives to meet customer needs, our concept includes, as a key element, a gain-sharing plan covering all team members working on a given contract.

Most Americans strongly believe in the advantages of a competitive market. For example, they are sure that consumers are better off as a result of the competition provided by a variety of food markets. This competition provides consumers with choices ranging from gourmet specialty shops to generic food warehouses. Each type of market fits into a particular niche and together establish limits on one another. The gourmet shop must carefully trade off additional service for prices that are higher than at the food warehouse. Other stores will try to provide a higher quality of service and a wider range of products because of the gourmet specialty shop. From the standpoint of price, quality, service, and available choices, consumers recognize that they are better served by competition and seldom view it as wasteful duplication. The same results apply to services such as dry cleaners, doctors, and lawyers.

When competition is absent and instead we have a monopoly controlling the market, we believe that customers will pay more for less output than would otherwise be the case. As illustrated recently, long-distance telephone service choices have increased because of deregulation, and rates have certainly fallen. Even those customers who haven't changed services have benefited from lower long-distance charges.

Regarding the provision of government services, however, people often lose sight of the basic theory cited above. In many cases we are persuaded that we will improve service and lower costs by consolidating offices "to avoid waste and duplication" even if it crates a monopoly. Although this concept has been readily rejected in commercial markets, many accept it in the case of government services.[1] Yet there is no technological advantage or economy of scale to be achieved by such a monopoly. The creation or continuation of such government monopolies provides less service at a higher cost, just as do monopolies in the private sector, than would individual offices competing for customers.

BACKGROUND

Over the past 40 years, numerous studies have addressed various acquisition problems. However, none has addressed the key issue of monopoly in the furnishing of contracting services. Currently, the customer is typically assigned to a particular contracting office and must accept whatever level of service is provided. The contracting office is often funded through a chain of command that is entirely different from that of the customer and whose goal is to provide service at lowest possible cost. While timeliness and customer satisfaction may also be stated goals, they will not be supported at the expense of increased costs.

This traditional arrangement for providing contracting services has resulted in widespread customer dissatisfaction. Customers frequently complain that they are not being given enough support, that contracting personnel are always telling them why something can't be done, that their contracts take too long (9 months or more) to be awarded, that too many personnel in the contracting office are poorly trained, and that the office is generally understaffed to provide the desired level of service. Customers seldom appreciate the fact that they do not have to pay for the services provided.

With contracting services provided free (at least as far as the customer is concerned), basic economic theory would lead us to expect that such services would be in high demand and that shortages would persist. This effect may be evident in the high (unmet) demands made by customers, as described above. Further, the customer incurs no financial penalty for inadequate planning or for providing poor statements of work and inadequate justifications for statutory exemptions. Nor are there penalties if documents require much rework or contracts constantly require modifications. The customer should bear the economic burden related to the level of service demanded.

To begin addressing these problems, we presented a paper[2] at the 1989 Acquisition Research Symposium pointing out the disadvantages of the current bureaucratic organization for contracting and suggesting the benefits of using an organic organizational structure following commonly accepted economic theory and practice. That paper, while it generated interest and some enthusiasm, left outstanding the implementation issues that would have to be resolved before the necessary organizational changes could be made.

SURVEY APPROACH

To explore implementation issues, including those raised by the participants at the 1989 Symposium, and to introduce a wider group of people to the notion of competition within government for the provision of services, we developed a condensed version of the concept and provided it to a sample of people interested in such services. The sample included individuals at all levels of government and industry involved in the provision or receipt of government contracting services. We asked them to comment on the concept, particularly on any impediments to implementation they could foresee.

Twenty copies of the condensed version were given to specific Members of Congress and executive branch officials involved in acquisition policy issues. An additional 15 were sent to leaders in industry. To get the views of the contracting practitioners, 30 copies were provided to individuals nominated to the National Contract Management Association for contracting achievement awards.[3] Other copies went to academics involved in public administration or procurement. Comments were also received in

response to its publication in *Contract Management*.[4]

Replies were received from Members of Congress, key congressional staffers, high-level executive branch officers and their aides and assistants, senior industry contracting professionals, and junior-level contracting personnel both from industry and from within the government. We received 28 replies, in addition to many discussions held by the authors spanning the past 2 years. While we do not claim statistical significance for the results of this survey, we believe they capture the viewpoints of a spectrum of policy and law makers, practitioners, and industry representatives.

SURVEY RESULTS

Survey responses ranged from very positive to very negative. More than half, interestingly enough, believed that contracting personnel were not strong enough to resist the temptation to satisfy the customer at the expense of regulatory and legal compliance. Another issue frequently raised was that the civil service system required changes to accommodate the personnel incentives. Several respondents challenged the economic rationale, mentioning that private industry had not established CCOs, believing that, if they were so efficient and cost-effective, industry would have already thought of doing so. Others noted, however, that private industry did not always do things right either, and so was not a perfect model to follow. Some cited the need to comply with socioeconomic goals and believed that compliance would be more difficult under CCOs. A few thought that the concept could not be implemented with the current poor level of training in the work force. Finally, there were a number of single comments on specific aspects of the concept. These comment areas, in addition to positive comments, are discussed below.

Positive Comments. Most of those responding recognized the potential that CCOs have for solving the problem of customer dissatisfaction with the services currently being received. They also recognized that the concept represents a positive cultural change in our view of contracting services. Finally, of those who mentioned the financial incentives, all believed that they would be effective in motivating management desire to improve customer satisfaction. Several believed that the incentives would further provide a basis for retaining the highly motivated, well-trained staff that management desires and the profession deserves, and thus would lead to more effective contracting.

Perceived Lack of Integrity. A large number of respondents opined that project officers would shop around to find a contracting office that would do what they desired without regard for law, regulation, or good business practice. This belief was accompanied by the parallel belief that if contracting officers relied on customers' financing of their operations, they would be motivated financially to violate laws, regulations, and good business practices to get the customer's business. This outlook was widely shared by many, including those directly involved in contracting.

Initially, of course, we realized that there might be temptation to engage in such behavior, and that a system of controls would be needed. The condensed version of the concept sent to those surveyed included a requirement for regular outside audits of the contracting office to establish accreditation to continue contracting activities. Those audits were to be supplemented by an internal peer review system requiring contracts over a certain value to be presented to a board at key milestone dates. Given their responses, it is clear that the reviewers

were not confident that these measures were sufficient to overcome temptation.

Since there are several other professions that may face similar temptations, we have briefly explored how they handle this issue. A similar conflict arises in the case of public corporations using outside auditors to certify their corporate financial reports. Corporations must find an accounting firm to certify that the report has been prepared in accordance with generally accepted accounting principles. Do accounting firms lacking integrity certify fraudulent books in return for their fees or for the prospect of more business? Although this practice does not appear rampant, it is known to have occurred, and many believe that the situation is getting worse.[5] The rate of dishonest activity by lawyers is also of increasing concern: ". . . while thieving by bad-apple barristers is nothing new, the practice seems to be on the rise. Moreover, when lawyers steal these days, they *are stealing more* than ever before. Special funds set up by state legislatures and bar associations to reimburse bilked law clients are facing unprecedented losses."[6]

The high esteem that has been traditionally reserved for professionals no longer exists. Recent court cases have been brought against dentists, lawyers, accountants, architects, and others for ethical abuses. "There's a growing perception that professionals have abused their autonomy and enriched themselves at the expense of their clients."[7] It may be that the low level of trust between professionals in procurement simply reflects this perception.

The perceived lack of integrity of the professionals who would operate the CCO remains the most difficult issue to resolve. It should be noted that if lack of integrity becomes the single issue preventing the CCO concept from being adopted, it must follow that the acquisition community at large is deluding itself in believing that it can function without the oversight and micromanagement of inspectors general, Congress, the General Accounting Office, and so on that it now claims it does not need.

It may be that our lack of belief in the ethics of others is actually part of a more general decline in socially cooperative behavior. Some researchers believe that the declines in voter turnout, charitable contributions, response to the census, tax compliance, and other areas are attributable to a 30-year decline in social cooperation. "Americans are becoming more mistrustful of their fellow-citizens. Since 1964, surveys have asked respondents whether they believe that 'most people can be trusted' or, alternatively, that 'you can't be too careful in dealing with people.' In all three polls conducted in the 1960s that asked this question, at least 53% of respondents agreed that people were generally trustworthy. In the 17 surveys conducted since 1970, the figure reaches as high as 51% only once (in 1976), and has often dipped into the upper thirties."[8] The perceptions of procurement professionals may be a reflection of this more general trend.

Civil Service System Requirements. Many respondents believe that the gain-sharing financial incentives contemplated under the CCO concept are precluded by the civil service system. The incentives include the possibility of regular, substantial bonuses for achievements in excess of established goals. While most agree that this approach would call forth superior efforts, they do not believe that such bonuses would be allowed. Current civil service regulations allow for Special Act awards when supervisors justify an employee's performance as greatly exceeding normal expectations. However, many believe that routine use of this authority would not be permitted. Other possibilities for monetary awards are special unit awards and those made

at end-of-year evaluation time. But these awards are quite limited in scope and applicability.

The CCO concept contemplates that awards for superior achievement would be generally accepted, with perhaps three or four such awards per year possible for certain high-performing individuals. For example, a contracting officer (and the team working with that contracting officer, including the contract specialist, typists, legal staff, mail room staff, and others involved in the procurement) could receive an award for completing a given contracting action in a manner exceeding agreed-upon goals related to timeliness, quality, or cost. This process could be repeated several times during the year, for each occurrence, an arrangement comparable to that in an employee-owned corporation that provides employees cash or stock bonuses based upon corporate performance.

The Office of Pe-s nnel Management (OPM) has noted that demonstration projects are authorized for up to 5,000 positions (see Title 5, United States Code (U.S.C.), Section 4701 et seq.). The law specifically provides that demonstration projects shall not be limited with regard to classifying positions, compensating employees, or providing incentives, including the provision of group or individual incentive bonuses or pay.[9] The law requires that no waiver be made regarding leave, insurance, or annuities; discrimination; or suitability, security, and conduct; or that is inconsistent with any merit system principle or that permits prohibited personnel practices.[10] None of these requirements affect the incentive provisions contemplated by the CCO concept. While it may be possible to implement CCOs within current regulations by using Special Act awards aggressively, a CCO clearly could be accommodated under a demonstration project.

The procedures for demonstration projects are well established. OPM is authorized to conduct and evaluate demonstration projects directly or through agreement or contract with one or more agencies and other public and private organizations. Before any demonstration, OPM is to develop a plan for the project, publish it in the Federal Register, and submit it to a public hearing. Notification must be provided to Congress and to employees who are likely to be affected. Each agency involved must approve the final version of the plan and provide Congress a report of the final plan at least 90 days in advance of the date the project is to take effect. The project can be stopped if necessary and may not run for more than 5 years. OPM, with the participating agencies, shall provide for evaluation of the results and their improvement of public management.[11]

Private Industry Doesn't Compete Contracting Services. Some respondents noted that private corporations do not compete contracting services between divisions. This fact was cited as a reason for doubting that the concept would succeed as designed.

Two survey responses were provided on this issue, one spontaneously and one in answer to our follow-up questioning, pointing out that industry does not always do the right thing, nor is it always the most effective or most efficient. While this is undoubtedly true, it was still uncertain whether the CCO concept would correct similar monopolistic problems within industry.

One program now becoming very popular in industry is total quality management (TQM). It provides a variety of methods and approaches to enhance the quality of an item or service through continuous process improvement. While this approach is useful in many cases, it is usually offered to enhance competition and is not incompatible with competition.[12] When competition can be introduced, its forces have a powerful

effect, requiring continuous process improvement on their own without the formalization of a TQM program.

When industry procurement professionals were asked how they met their internal customers' needs for responsive service, we learned that they do not. Their customers have the same complaints: it was needed yesterday; contracting doesn't understand; the administrative paper-pushers in contracting take too long.

Some companies have made strides towards adopting internal competition for a variety of service functions, and some government agencies are also attempting to do so.[13] One of the largest of these programs is being carried out by Bell Atlantic. While the program does not extend to the contracting operation specifically, the concept is the same, and Bell Atlantic generally considers internal competition for services a success.[14]

While we have not studied the appropriate size for a competitive contracting office, we believe that it may be an office of perhaps 50 contracting professionals. While offices of that size or larger are frequently found within government, they are infrequently found within industry. We only suggest competition where efficiently sized offices would compete. However, we do believe that the CCO concept is applicable to industry use as well, and we propose its use for very large firms able to support the internal competition.

Socioeconomic Goal Achievement. Some individuals surveyed pointed out that if the customer objects to contract awards to achieve socioeconomic goals, the CCO might be in a poor position to insist, for fear of losing the customer's business.

This could be a problem if the achievement of socioeconomic goals remains a responsibility of the contracting office, but it would be resolved if responsibility were placed on the project office or other customer. In that case, certain CCOs might decide to specialize in meeting such customer needs. For example, a contracting office or a division of an office might view this as a market niche, providing special service to help customers meet socioeconomic requirements, by offering special expertise in locating 8(a) or small business firms qualified to do the work.

Poorly Trained Work Force. Some of those surveyed believed that the current contracting work force is insufficiently trained to make the CCO concept work. They suggested that the level of expertise of the work force would have to be substantially improved before there could be a meaningful competition between offices. And, indeed, numerous studies have shown the need for a better trained and better qualified, more competent work force.[15]

We believe that adopting the CCO concept will lead to a better work force. In a competitive environment, customers will demand well-trained professionals to accomplish their work, and contracting offices will find it to their advantage to have such a work force. This goal may well be achieved by paying a premium to attract and retain the best qualified personnel, a premium made possible by superior performance that attracts customers. Although one respondent believed that the current work force is too immobile for CCOs to succeed, we find no evidence that this is so. In fact, several practitioners welcomed the opportunity provided by such an environment, which could become the attraction to keep intelligent, highly trained people in government rather than losing them to industry.

Contracting officers will find it beneficial to assemble a highly skilled team capable of meeting customers' expectations, in order to receive bonuses for exceeding pre-established goals. The promotion of education and training to

make more effective contracting professionals will thus become a joint desire of the individual, the supervisor, and the customer. Conversely, those not sufficiently motivated to seek knowledge and learn from experience will fall by the wayside.

Other Comments. Each issue discussed above was raised by more than one person surveyed. A number of other, single comments are also worthy of note. One person commented that CCOs would spend too much time trying to attract customers. Another said that the proposed system would result in a wasteful duplication of effort. Both considerations are easily put aside by looking at services provided in the private sector. We do not find competition in the private sector wasteful duplication of effort. We understand that it provides us with a variety of choices enabling us to best meet our needs. Competition provides the required quality of services at the lowest price. Having a government monopoly to reduce wasteful duplication violates basic economic theory. (The case of natural monopolies, such as public utilities, is an exception that does not apply here.) As to the amount of effort expended on attracting customers, it will be self-policing, as each manager balances the cost and benefits of that effort – just as in industry. With the entire budget dependent on fees for services provided, the optimum amount of time or money will be spent to attract customers.

One person pointed out that adopting the CCO concept would result in extra work for program managers, to shop around. Of course, they do not need to shop around if they are satisfied with the service they are currently receiving. If they are not, they will be motivated to shop around. Another person said that the CCO concept is not needed, because large programs are already competed between offices. But we feel that this is an argument for CCOs, that *all* should enjoy the ability to pick their contracting office. Certainly in those cases where choice is now possible, customers do take full advantage of it. Thus we know it is desirable, and we have not heard complaints that selecting a contracting office involved burdensome or unnecessary extra work.

Two other respondents pointed out that there are too many laws. Another pointed to the general problem of micromanagement as being the reason for customer dissatisfaction, saying that curing it is what is needed, not CCOs. While having CCOs would not eliminate any of the current procurement laws or regulations or the problem of micromanagement, each CCO would be motivated to work for relief, perhaps via waivers, of requirements limiting the quality of service that they could provide. Currently, in the absence of incentives to provide superior service, unneeded laws and regulations are not effectively opposed; in fact, they are frequently hidden behind to protect inefficiency and nonresponsive and reactionary behavior.

One person believed that too many recent changes have already taken place to consider any more at this time; another recognized that the concept indeed represents a fundamental cultural change and considered it therefore too difficult to pursue. In contrast, we do not believe that it will be fruitful to wait for a quiet period in the area of procurement before acting; such a period is unlikely to occur. While the introduction of CCOs represents clearly a cultural change, such a change is exactly what is needed – as is often pointed out by critics and by leaders in industry and government – to make any significant improvement in the provision of contracting services.

Another respondent asserted that the benefits would not warrant the difficulty of introducing CCOs. While the truth of this assertion may not be able to be determined for several years after CCOs are introduced, we believe that – given

the proven and acknowledged benefits of competition – there is little doubt that benefits will far outweigh costs. Difficulty of implementation is not a sufficient excuse in this case, if in any.

One person believed that introducing CCOs would lead to the loss of surge capability as less efficient competitors are pared away. However, as far as we can determine, there is no current ready surge capability to be lost. Nearly all contracting offices are working near capacity at all times. It is not clear that having CCOs would improve surge capacity, but we fail to see how it would make it worse.

Finally, one person believed we should contract out to industry for contracting services. While we are not prepared to take this leap, he assured us that the company he worked for was ready to accept the contract.

AREAS FOR FURTHER STUDY

Ethics. We believe that the key issue for further study is that of the integrity of the procurement work force. Two approaches are possible: first, devise methods of preventing unethical behavior; or, second, ensure that only ethical people are in the CCOs. Probably some combination of the two approaches is most reasonable, but how much of each should be used?

With 50 percent of the respondents citing ethics as a major problem for the CCO concept, it is important to determine whether there is actually a low level of integrity within the contracting community or whether it is a matter of perception, fueled by a few well-publicized cases such as those in the Ill Wind operation. Notwithstanding the comments we received on ethics, senior levels of government continue to hold that nearly all professionals in contracting are ethical and that the bad apples are few and far between. This disparity must be resolved before further progress can be made on implementing the CCO concept.

Competition Within Private Corporations. How much is competition used within corporations, and how effective is it? One approach to competition is the make-or-buy decision. Another is the use of competing divisions or units within the same corporation. What are the effects on management of the units when they face external or internal competition – do they respond by trying to meet their customer's needs by reducing costs, increasing quality, being more timely, or does some other type of behavior occur? Is internal competition counterproductive to the efforts of TQM?

CONCLUSIONS/SUMMARY

There is universal agreement that the current situation is undesirable: customers are unhappy with their level of service, and contracting personnel are unhappy with the conditions in which they operate. In contrast, many contracting professionals find it very exciting to contemplate the opportunity of being paid on the basis of performance.

Many find it easy to believe that the benefits of competition for the customer's business would be fully realized under the CCO concept. They think that more timely service and better meeting of the customer's needs would result. Having customers choose and pay for the services received would help ensure that the customer's needs are met.

Procurement professionals also believe that both they and the procurement system would be better off if they were paid according to their work effort. Such a system would separate the wheat from the chaff in the work force.

While many see benefits in having the customer pay for services received and

having the individual service provider receive part of that payment, half of the respondents saw danger that the concept would result in violations of regulations or good business practice due to a lack of ethics. This may be the case even if the financial rewards do not go to the individual personally but accrue to the CCO, allowing it to survive and perhaps grow.

Although some concern was expressed over the civil service implications, we believe that this concern has little merit, at least under an authorized demonstration program. Even without the benefits of a demonstration program, the civil service system, we believe, will accommodate the CCO concept.

In a cover story discussing motivation of managers, *Business Week* offered several suggestions: turn over more responsibility to managers; tie managers' raises to performance, not seniority; give them more power; offer them lateral movement and don't penalize managers who prefer to remain in the same positions; offer managers offshore moves; and provide them mid-career breaks, such as management development programs.[16] The CCO concept provides several of these motivational approaches automatically and makes others possible.

In a recent article, Jackie Ducote reports that, after over 10 years of actively working at the state level to reform the educational system, results have been minimal. "Piecemeal attempts to change the present system haven't worked and won't work because the present system is a monopoly. . . . The single most important thing the business community can do is unleash a self-perpetuating, external force for change that is free from the control of those who have been in charge of our failed education system in the past. . . . That force is competition."[17] The same principles apply to procurement reform.

This concept is not limited to the provision of contracting services. The same concept can provide the benefits of competition in furnishing any type of services wherever two or more minimum-efficient-size service units can exist. More research should be undertaken to determine how similar current competitions are operating and why the concept has not been extended to other areas.

ENDNOTES

1/ David Osborne, "Ten Ways to Turn D.C. Around," The Washington Post Magazine, December 9, 1990. In citing successful examples, Mr. Osborne makes the point that the important distinction is not public versus private, but monopoly versus competition.

2/ Karen D. Sorber and Ronald L. Straight, "Competitive Contracting Offices: An Alternative to a Separate Acquisition Corps," Proceedings, 1989 Acquisition Research Symposium, pp. 287–294.

3/ A copy was sent to each Blanche Witte Memorial Award winner and nominee as reported in the April 1990 issue of *Contract Management*.

4/ Ronald L. Straight and Karen Sorber Dean, "Competition Within Government," *Contract Management*, November 1990, pp. 18–21.

5/ Albert B. Crenshaw, "Accountants Do Bitter Battle for New Clients," Washington Business, *The Washington Post*, April 23, 1990, p. 5. This was also separately confirmed by interview with a major accounting firm partner.

6/ Amy Dockser Marcus, "Thievery by Lawyers is on the Increase, with Duped Clients Losing Bigger Sums," *The Wall Street Journal*, November 26, 1990, pp. B1, B4.

7/ "Pressure on Professionals," *Business Week*, July 23, 1990, pp. 24–25.

8/ Stephen Knack, "Why We Don't Vote – Or Say 'Thank You,'" *The Wall Street Journal*, December 31, 1990, editorial page.

9/ 5 U.S.C. 4703(a).

10/ 5 U.S.C. §4703(c).

11/ 5 U.S.C. §4703(b), (d), and (e)

12/ Brian E. Mansir and Nicholas R. Schacht, *An Introduction to the Continuous Improvement Process*, Logistics Management Institute, August 1989, p. 2-1.

13/ Osborne, op cit.

14/ Julia A. Lopez, "At Bell Atlantic, Competing Is Learned From the Inside," *The Wall Street Journal*, July 12, 1989, p. B2.

15/ Such studies include the second Hoover Commission (1955), the Fitzhugh Commission (1970), the Commission on Government Procurement (1972), the Packard Commission (1986), and others.

16/ "Farewell, Fast Track," *Business Week*, December 10, 1990, pp. 192–200.

17/ Jackie Ducote, "Confessions of an Education-Reform Junkie," *The Wall Street Journal*, December 14, 1990, editorial page.

COMPETENCIES OF FUTURE DEFENSE ACQUISITION PROGRAM MANAGERS

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ABSTRACT

The progra·n manager will almost certainly be at the heart of imagination and innovation in the future of defense acquisition. This paper summarizes the results of a study which characterized top performing program managers in the U.S. Department of Defense (DoD). A similar study is being conducted in the U.K. Ministry of Defense. The research data base now includes over 75 in-depth interviews and 300 written surveys. This paper will use the research findings to focus on four key areas which must be considered in developing future program managers: 1) defining program manager competency requirements, 2) selecting the best program manager candidates, 3) assessing and 4) developing their competencies.

INTRODUCTION

The world of defense acquisition is constantly changing, and this is never more true than today. With the Defense Authorization Act for Fiscal Year 1991 has come direction to establish a professional acquisition corps in each service as well as training, education, and experience prerequisites for assuming increasingly responsible management positions in these corps. DoD has also been tasked to create a university of acquisition management and a senior (war college-level) acquisition course to facilitate the development of trained acquisition professionals.

PROGRAM MANAGER COMPETENCIES

A major issue which emerges in planning for the acquisition corps is identification of the most important skills or competencies which will be required of senior acquisition managers in these new organizations. Rather than postulate what these skills ought to be, a useful starting point would be to look at the skills being demonstrated by effective managers in current acquisition organizations. In 1989, DSMC completed an extensive study which identified the competencies of a select group of program managers from the service acquisition commands. The study results were published in several Program Manager (DSMC journal) articles[1,2,3] and are summarized in Figure 1. Note that six of the competencies (denoted with *) were found to distinguish the outstanding program managers from their contemporaries, and these competencies dealt almost exclusively with managing the external environment (i.e., outside the program office).

Another interestir · finding from the study emerged from the mparison of importance rankings of the competencies by program managers and other acquisition professionals (managers from different acquisition specialty areas such as contracting, budgeting, engineering, and logistics). This comparison is illustrated in Figure 2. It is clear from the figure that there are some significant differences in the competency rankings between the two groups. The acquisition professionals (functional managers) considered technical expertise, attention to detail, and creativity (defined as developing novel technical solutions as far

FIGURE 1. PROGRAM MANAGER COMPETENCY MODEL

(Numbers below do not indicate order of importance)

Managing the External Environment

- *1. Sense of Ownership/Mission
- *2. Political Awareness
- *3. Relationship Development
- *4. Strategic Influence
- *5. Interpersonal Assessment
- 6. Assertiveness

Managing the Internal Environment

- 7. Managerial Orientation
- 8. Results Orientation
- 9. Critical Inquiry

Managing for Enhanced Performance

- 10. Long-term Perspective
- 11. Focus on Excellence
- 12. Innovativeness/Initiative
- 13. Optimizing
- 14. Systematic Thinking

Proactivity

- *15. Action Orientation
- 16. Proactive Information Gathering

*Denotes competencies which distinguish outstanding from effective program managers (at $p < .03$) based on frequency of demonstration

Competency Definitions

1. Sense of Ownership/Mission. Sees self as responsible for the program; articulates problems or issues from broader organizational or mission perspective.

2. Political Awareness. Knows who influential players are, what they want and how best to work with them.

3. Relationship Development. Spends time and energy getting to know program sponsors, users and contractors.

4. Strategic Influence. Builds coalitions and orchestrates situations to overcome obstacles and obtain support.

5. Interpersonal Assessment. Identifies specific interests, motivations, strengths and weaknesses of others.

6. Assertiveness. Takes or maintains positions depite anticipated resistence or opposition from influential others.

7. Managerial Orientation. Gets work done through the efforts of others.

8. Results Orientation. Evaluates performance in terms of accomplishing specific goals or meeting specific standards.

9. Critical Inquiry. Explores critical issues that are not being explicitly addressed by others.

10. Long-term Perspective. Anticipates and plans for future issues and problems.

11. Focus on Excellence. Strives for the highest standards regardless of circumstances.

12. Innovativeness/Initiative. Champions and pushes new ways of meeting program requirements.

13. Optimizing. Makes decisions after carefully evaluating advantages and disadvantages.

14. Systematic Thinking. Organizes and analyzes problems methodically.

15. Action Orientation. Reacts to problems energetically and with a sense of urgency.

16. Proactive Information Gathering. Systematically collects and reviews information.

FIGURE 2. SURVEY VALIDATION OF PM COMPETENCIES

Competencies*	RANK ORDER OF IMPORTANCE Program Managers (N = 128)	Other Acq. Professionals (N = 225)
SENSE OF OWNERSHIP/MISSION	1 ←	17
LONG-TERM PERSPECTIVE	2	6
MANAGERIAL ORIENTATION	3	2
POLITICAL AWARENESS	4 ←	21
OPTIMIZING	5	5
RESULTS ORIENTATION	6	8
SYSTEMATIC THINKING	7	3
INNOVATIVENESS/INITIATIVE	8	11
FOCUS ON EXCELLENCE	9	9
ACTION ORIENTATION	10	10
RELATIONSHIP DEVELOPMENT	10	14
coaches others	12	12
PROACTIVE INFORMATION GATHERING	13	15
STRATEGIC INFLUENCE	14 ←	23
creativity	15 →	3
self control	15	13
INTERPERSONAL ASSESSMENT	17	18
collaborative influence	18	16
CRITICAL INQUIRY	18	24
positive expectations	20	24
technical expertise	21 →	1
interpersonal sensitivity	22	22
attention to detail	22 →	7
ASSERTIVENESS	24	20
efficiency orientation	25	18
directive influence	26	26
competitiveness	27	27

*Upper case = final PM competencies; lower case = other competencies included in the survey.

more important than did program managers. On the other hand, program managers rated sense of ownership/mission, political awareness, and strategic influence much higher than functional managers. These are also 3 of the 6 critical competencies which characterize outstanding program managers (from Figure 1). An underlying issue emerges from the difference in competency requirements for program managers and acquisition specialists; the transition from functional specialist to program manager may be conceptually quite difficult. A review of the literature supports this conclusion[4], especially for scientists and engineers who currently make up the bulk of acquisition program managers.

Another historical source of program managers has been the operational community in each service, i.e. war fighters. The thought behind selecting operational commanders was that they had both leadership skills and first hand experience in the user environment. Some also had technical backgrounds (usually not current) and others did not. Even with this group, significant competency differences for the program manager role are still envisioned. In competency research studies of Navy operational commanders[5,6], many of the same competencies from the Figure 1 program manager list emerged. However, many competencies such as political awareness and strategic influence from the most critical area of Managing the External Environment were not as evident. An interesting observation from these limited data is that program managers need external interface skills to a much greater extent then their counterparts in operational commands. In this respect, program managers may more closely resemble higher level operational commanders (i.e., general/flag officers). However, with the creation of the service acquisition corps, it is unlikely that future program managers will be drawn from the operational ranks. This still leaves the problem of transitioning the technical specialists (scientists and engineers and perhaps business specialists) into program managers.

Three issues must be considered in structuring an effective transition process to develop future program managers: candidate selection, competency assessment, and competency development. Each will be discussed in more detail in the remainder of this paper.

PROGRAM MANAGER SELECTION

Selection of program managers is currently conducted by special panels in the service acquisition commands. Although future potential is considered, most of the evaluation is of necessity based on the candidates' performance in their prior jobs. However, the conclusion made earlier in this paper is that there are several unique program manager competencies not normally required of more junior acquisition professionals. Further, these competencies or skills are by their nature complex and generally developed only with time and experience. This would suggest that selection of program manager candidates should be based to at least some degree on their possession of or disposition toward acknowledged critical program manager skills. The argument then becomes how to assess which candidates have or can more readily develop these critical competencies.

COMPETENCY ASSESSMENT

Assessing program manager candidates' ability to perform critical management and leadership skills is a difficult proposition.

This is due in part to the fact that many of these competencies were not required to a great degree in candidates' prior jobs. However assessment techniques have emerged in recent years which may be useful. Tailored survey assessment instruments can be created and given to candidates' prior supervisors, peers, and subordinates asking for their assessment of the candidates' past performance and future potential in each of the program manager competency areas. Another useful method is the critical behavior interview approach used in DSMC's competency research. Here, the program manager candidate is asked to recount several significant prior job situations of their own choosing. In each situation, the interviewer listens and probes for detail seeking to identify which competencies the candidate has used (and not used) in the past. Such discussions often cut through generic statements of capability and accomplishment by the candidates to what they actually did in more stressful situations. Clearly, no program manager career development model will be complete without a credible assessment process.

COMPETENCY DEVELOPMENT

Even with effective assessment and selection processes, further improvement of critical program manager skills will be quite desirable for all program manager candidates, even the most competent. Efforts to achieve this improvement should be directed both on the job and in the series of professional training opportunities which will be associated with the acquisition corps. Several self-development and training methodologies exist which can be adapted for this role. These include the competency assessment instrument and critical behavior interview described earlier. In addition, case studies and experiential exercises could prove quite effective in addressing program manager competencies, when imbedded in established training programs. Case studies based on past acquisition programs can bring the real world dimension to the classroom and provide additional focus on program manager unique skill requirements. Several such "real world" cases have been developed, some of which are now in use at DSMC. Experiential exercises can add the behavioral dimension to the classroom environment. Program manager candidates can be put into realistic situations and asked to respond, not by stating what they would do in the situations, but by actually doing it. Here, understanding is only the first step in mastering the complex set of program manager competencies. "Unfortunately, it is usually not the lack of knowledge, but the inability to use knowledge that limits effective managerial behavior." [7] DSMC already uses such behavioral simulations extensively in their Program Management Course.[8] Examples are the Systems X Case Program and the Looking Glass Management Simulation. New acquisition-based simulations are also being developed. These simulations offer the program manager candidates the opportunity to integrate their acquisition knowledge with the complex managerial leadership skills necessary to be effective in the real world acquisition environment.

SUMMARY

The role of the program manager has and will continue to be a corner stone of the acquisition process. As such, it requires a unique set of competencies focused extensively on managerial and leadership skills. But considerable planning and attention must be applied now to ensure that future program managers will have the prerequisite skills. This includes carefully

structuring processes for selection, assessment and development of program managers with the right competencies for the complex acquisition environment of the future.

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PROGRAM MANAGEMENT

from A to Z

PREDICTING FINANCIAL DISTRESS IN DEFENSE CONTRACTS

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ABSTRACT

A contractor's financial capability is evaluated in source selection, and monitored after the contract is awarded. A model that reliably predicts financial distress would be a valuable tool in both preaward and postaward evaluations. Although many published statistical models have been developed to predict financial distress, only two have been based on defense contractor data. This paper evaluates four existing models and develops a new one based on data from defense contractors that have gone bankrupt. The new model regresses selected financial ratios using logit and multiple discriminant analysis. Methodological weaknesses are identified and ways for improving the reliability of financial distress models are suggested.

INTRODUCTION

The Air Force has contracts with a myriad of corporations worth billions of dollars. Before a contract is awarded, financial analysts and auditors are required to look at the financial health of the bidders to determine whether they can stay in business long enough to complete the contract. Dealing with a contractor that is having financial problems can be costly. Government analysts use various methods of assessing a contractor's financial health, such as ratio analysis of the contractor's financial statements and interviewing the contractor's banker. A useful addition to the analyst's tool kit would be a model to reliably predict financial distress.

Although many financial distress models have been reported, only two are specific to the defense contracting industry. Presumably, unless the model is based on data from the defense contracting industry, it is unlikely to be reliable enough for the government to use in source selection or postaward evaluations. The *Defense Contract Audit Manual* [3:453] describes one distress model. Although the source of the model is not referenced, it is identical to the model reported by Altman [1] and is therefore not defense industry specific. Despite this apparent weakness, auditors are encouraged to use the model in financial capability reviews. The two models based on defense data have not been adopted by government analysts or auditors.

In developing financial distress models, linear discriminant analysis is the technique most commonly used, although recently there has been more interest in logit analysis. In general, the linear discriminant analysis model is:

$$Z_i = a + \mathbf{b}X_i + u_i \quad (1)$$

where **b** is a vector of coefficients determined by regressing selected financial ratios, X_i, against the binary dependent variable, Z_i; a is the intercept; and u_i the error term. Z_i typically takes the value of 0 for bankrupt firms, and 1 for nonbankrupt firms. Bankruptcy is not the only indicator of financial distress, but is the dependent variable most often used. Most of the reported models are multivariate. Of the two models based on government contractor data, one used multidiscriminant analysis and the other used a combination of multidiscriminant and univariate analysis.

Using defense contractor data, this study evaluated the reliability of four financial distress models, and developed a new model based on discriminant and logit analysis. To investigate the effectiveness of generalized models in predicting financial distress in defense contractors, two of the more widely publicized models [1,9] were evaluated. The other two models [2,7] evaluated were developed based on government contractor data.

Table I summarizes the four models evaluated here. Each was developed by regressing selected financial ratios from samples of bankrupt and nonbankrupt companies matched by asset size and time period. Bankruptcy is then predicted by entering a given company's ratios into the model and computing the value of dependent variable, termed the "Z-score" in discriminant analysis models.

Depending on the Z-score, the company is classified as either bankrupt or nonbankrupt. The cut-off point depends on the particular model, and is chosen to minimize some objective function, usually the number of misclassifications. In the original discriminant analysis model reported by Altman and used by the Defense Contract Audit Agency, a company is classified as likely to go bankrupt when the Z-score is less than 1.81. The reported misclassification error rate was 5 percent.

METHODOLOGY

Financial distress. Financial distress may be defined as severe liquidity problems that cannot be resolved without drastic changes to the organization, such as rescaling operations or filing for bankruptcy. Clearly, financial distress is an economic condition that involves many factors. While the dichotomous classification of companies as either bankrupt or nonbankrupt is a gross oversimplification, it is used in this study and most other distress studies as a convenient way to operationalize financial distress.

Various kinds of data may be useful in assessing the likelihood of financial distress, such as the quality of a firm's management, security returns, bond ratings, the inflation rate, and the unemployment rate. Financial statement data, such as liquidity or earnings ratios, are the most commonly used indicators of financial distress, and were used in this study to develop the distress model.

Selecting the sample. To test the four models and develop a new model, a sample of defense contractors that have gone bankrupt was needed. A list of 150 government contractors who filed for bankruptcy was compiled from Air Force Accounting and Finance Center records. Finding financial data on these failed contractors was difficult. From a search through Moody's manuals, Q-File, Disclosure Database, and Compustat, financial data on only five of the 150 contractors were available.

In order to develop a larger sample, names of bankrupt companies judged likely to have done business with the government were obtained from the 1988 Securities and Exchange Commission's *Annual Report* and the *Wall Street Journal Index*. Using Standard and Poor's Compustat database, financial data for 13 of these bankrupt companies were collected, bringing the total of bankrupt companies to 18.

Financial data on 18 healthy companies matched to the bankrupt companies by Standard Industrial Classification (SIC) and size of assets were then extracted from Compustat. The names of the bankrupt and matched companies used in

TABLE I

COMPARISON OF FOUR BANKRUPTCY PREDICTION MODELS

Researchers (date)	Type of Business	Sample Size	Matched By	Statistical Method	Ratios Used in Model	Misclass Rate (%)	Validation Method
Altman (1968)	Manufacturing	79 Failed 79 NonFail	industry, assets, year	Discriminant Analysis	Work Cap/Tot assets Ret Earn/Tot assets EBIT/Total Assets Mkt Val Equity/ Total debt Sales/Total assets	5	Holdout sample
Dagel & Pepper (1990)	Manufacturing	28 Failed 28 NonFail	time period	Discriminant Analysis	Tot debt/Tot assets Cash flow/Tot debt Cur assets/Cur Liab Quick assets/Tot assets Net sales/Tot assets Work cap/Tot assets	3	Holdout sample
Moses & Liao (1987)	Government contractors	26 Failed 26 Nonfail	assets	Univariate & Discriminant Analysis	Net Worth/Tot assets Work Cap/Tot assets Sales/Tot assets	19	Split sample
Zavgren (1983)	Industrial	45 Failed 45 Nonfail	industry, assets	Logit	Tot Inc/Tot capital Sales/Net plant Inventory/Sales Debt/Tot Capital Receiv/Inventory Quick Assets/Curr liab Cash/Total assets	18	None

this study are not provided.

Selecting the financial ratios. In the absence of any theory regarding which ratios are appropriate predictors of financial distress, most researchers have selected ratios based on judgment, or have exhaustively searched for ratios that minimize prediction error. In this study, twenty ratios were placed into seven categories described by Pinches *et al.* [8] in their factor analysis study of business ratios. According to Pinches *et al.*, by choosing one ratio from each category, the fullest descriptive capability will be maintained as well as the independence of the ratios. However, it was found that dividing the ratios into the seven categories did not completely eliminate significant collinearity between some ratios of different categories. The categories and ratios used in this research are shown Table II. Statistics for each ratio for both bankrupt and nonbankrupt companies are shown in Table III.

Of special interest in Table III is the column listing the difference in the means between the bankrupt and nonbankrupt companies. The means of seven ratios (CF/S, CF/TD, INC/TC, LTD/TC, NI/S, S/TA, S/TA, TD/TA) are higher for the bankrupt than for the nonbankrupt companies. Higher means would be expected only for the LTD/TC and TD/TA ratios. A model using these ratios may thus discriminate for this sample, but give misleading results in making predictions on other companies.

Table III also reports the results of paired-t tests, which tested whether the difference between the individual ratio means of the two samples are significant. As can be seen from the last column in the table, even at the 20% significance level, only 11 of the 20 ratios have means that are significantly different.

Both the paired t-test and discriminant analysis assume that the populations are normally distributed. Therefore, the ratios were analyzed to determine which exhibited a normal distribution. Ratios not exhibiting a normal distribution were: LTD/TC and S/WC for the bankrupt sample and C/S, C/FS, CF/TD, LTD/TC, NI/S, QA/CL, and S/R for the nonbankrupt sample.

Validation of Error Rates. Several methods can be used to determine the model's prediction error rate. The most direct method is to predict the status of each company in the estimation sample. This is the method used initially to report the error rates in most studies, including the four evaluated in this paper.

This *apparent* error rate is clearly biased. Testing the model by entering the same observations that the model was built with will tend to make the model predict better than would be the case when testing the model with new observations. Also, given the potential for overfitting the data by systematically searching for combinations of ratios that yield the best predictions, it is especially important to validate the model against data not included in the estimation sample. Thus, the four studies reviewed in this paper also used "holdout samples" to validate the results.

But the use of a holdout sample is a problem when the sample size is small. Lachenbruch [6] has recommended another approach, where each company is sequentially excluded from the estimation sample. Models estimated on the remaining sample are then used to predict the status of the withheld company. The overall predictive accuracy of the model is tabulated as the percentage of the sequentially withheld companies whose status was correctly predicted.

TABLE II

FINANCIAL RATIOS (ACRONYMS) BY CATEGORY

Profitability	
Cash flow/Total Debt (CF /TD)	
Earnings before income and taxes / Total assets (EBIT/TA)	
Income before discontinued operations and extraordinary items / Total capital (INC/TC)	
Net income / Sales (NI/S)	
Net income / Total assets (NI/TA)	
Capital Turnover	
Cash flow/ Sales (CF/S)	
Sales / Net plant (S/NP)	
Sales / Total assets (S/TA)	
Inventory Turnover	
Sales / Working capital (S/WC)	
Financial Leverage	
Long-term debt / Total capital (LTD/TC)	
Net worth / Total assets (NW/TA)	
Retained earnings / Total assets (RE/TA)	
Total debt / Total assets (TD/TA)	
Receivables Turnover	
Sales / Receivables (S/R)	
Liquidity	
Current assets / Current liabilities (CA/CL)	
Quick assets / Current liabilities (QA/CL)	
Working capital / Total assets (WC/TA)	
Cash Position	
Cash and equivalents / Current liabilities (C/CL)	
Cash and equivalents / Sales (C/S)	
Cash and equivalents / Total assets (C/TA)	

TABLE III

RATIO STATISTICS FOR BANKRUPT AND NONBANKRUPT COMPANIES

	Bankrupt Companies				Nonbankrupt Companies				Difference between	Difference *** significant at:		
Ratios *	Mean	Max	Min	Std Dev	Mean	Max	Min	Std Dev	means **	5%	10%	20%
C/CL	0.09	0.37	0.00	0.11	1.22	14.94	0.01	3.44	1.14			x
C/S	0.05	0.41	0.00	0.10	4.22	74.00	0.00	17.41	4.18			
C/TA	0.04	0.23	0.00	0.06	0.15	0.85	0.01	0.19	0.11	x	x	x
CF/S	0.33	0.13	-1.69	0.50	-3.12	0.18	-52.95	12.46	-2.79			
CF/TD	0.30	0.10	-0.95	0.34	-0.70	0.31	-10.69	2.55	-0.40			
CA/CL	1.20	3.06	0.19	0.83	2.59	15.21	0.57	3.35	1.39		x	x
EBIT/TA	-0.30	0.12	-2.23	0.52	-0.11	0.16	-0.94	0.32	0.19			x
INC/TC	0.63	7.79	-2.92	2.06	-0.51	1.24	-6.66	1.77	-1.14		x	x
LTD/TC	3.60	79.64	-10.41	19.14	2.78	66.37	-18.96	16.52	-0.82			
NI/S	-0.37	0.08	-1.84	0.52	-3.22	0.14	-53.76	12.64	-2.85			
NI/TA	-0.39	0.05	-2.33	0.54	-0.15	0.10	-0.93	0.31	0.24		x	x
NW/TA	-0.01	0.56	-1.35	0.53	0.32	0.94	-1.31	0.47	0.33	x	x	x
QA/CL	0.60	2.12	0.08	0.60	1.75	15.08	0.34	3.38	1.15			x
RE/TA	-0.41	0.48	-2.00	0.60	-0.24	0.48	-2.59	0.75	0.17			
S/NP	7.15	22.93	0.80	5.60	7.87	37.50	0.29	9.93	0.71			
S/R	13.46	72.12	1.24	16.91	26.92	333.85	1.50	77.43	13.45			
S/TA	1.86	5.07	0.42	1.40	1.22	2.89	0.01	0.72	-0.64			x
S/WC	-23.63	52.89	-471.46	113.42	5.74	95.67	-41.30	25.93	29.36			
TD/TA	1.01	2.35	0.44	0.53	0.68	2.31	0.06	0.47	-0.33	x	x	x
WC/TA	-0.18	0.41	-1.74	0.62	0.23	0.81	-0.30	0.31	0.41	x	x	x

* Definitions of ratio acronyms are in Table II

** Nonbankrupt means - bankrupt means

*** Based on paired t-tests

RESULTS

Predictive accuracy of the four models. Entering the financial information from the samples of bankrupt and nonbankrupt firms into the four models showed that the models were less successful predicting bankruptcy than reported in the original studies (Table IV). Furthermore, the assumption that models developed from government data would do better than the generalized models is not supported by the results.

TABLE IV

ACCURACY RATES

Model	Original	Actual
Altman	95%	56%
Moses/Liao	81%	56%
Dagel/Pepper	97%	50%
Zavgren	82%	47%

Factors related to the reduced accuracy of the four models include collinearity, oversampling of bankrupt companies, and misclassification costs. Collinearity becomes a problem when the model is used to predict over a different time period than that used to build the model. For a model with collinear variables to remain a good predictor, the collinear variables should stay related to each other in the same way over time. The four models were based on financial data from different time periods than tested in this study.

With regard to oversampling and misclassification costs, none of the four models appeared to take either into account when reporting their accuracy/error rates. Using a sample of 50% failed and 50% nonfailed firms is unrepresentative of the ratio of failed to nonfailed firms in the population. The oversampling of distressed firms can overstate the predictive accuracy of the model. Similarly, the cost of classifying a failed firm as nonfailed (Type I error) is much higher than the reverse (Type II error), and should be considered when assessing predictive accuracy.

Because the models evaluated did not predict as well as reported when using government contractor data, a new model was developed using logit and discriminant analysis.

Logit Analysis. The statistical package LIMDEP was used to develop a bankruptcy prediction model using logit analysis. The logit analysis function is expressed by a cumulative distribution:

$$F\{Z\} = 1/(1+e^{-z}) \qquad (2)$$

where Z_i = $\mathbf{b}X_i$ with b the vector of coefficients and X_i the financial ratios for i = 1 to N companies. The method of maximum likelihood is used to estimate the model parameters. Because the parameters b_i are nonlinear, numerical search methods must be used. Once the maximum likelihood estimates are found, they can be substituted in the logit analysis function. Substituting the identified ratios for the X_i in this function provides the fitted response for each case.

Over 200 models were tested. The first 130 models consisted of one ratio from each of the seven categories described by Pinches, *et al.* Based on a 50% cutoff point, four of these models predicted 33 out of 36 cases correctly (92% accuracy). However, each of these models had three or four coefficients with the wrong sign. Also, all of the models had five or six variables that were insignificant at the 10% significance level. The cash position ratios--C/CL, C/TA, and C/S--were significant at the 5% level for almost every model. Other ratios with relatively

low (10%) significance levels for many models were CF/TD and NI/TA (profitability ratios), CF/S (capital turnover), and QA/CL (liquidity).

Additional models were tested by dropping the most insignificant variables and/or dropping variables with the wrong sign. While this improved neither the prediction accuracy nor the log-likelihood and chi-square statistics, some of the resulting models were more meaningful with coefficients of the correct sign and with improved statistical significance.

The best resulting multivariate model included CF/TD, S/WC, and C/TA. The coefficients had the correct signs and moderately successful prediction rates. Because there was a high degree of correlation between CF/TD and C/TA, additional tests demonstrated that dropping S/WC and CF/TD did not significantly affect performance at the 5% significance level. Therefore, the best model was univariate with C/TA as the sole ratio, where

$$Z_i = 1.23147 - 17.6537\ C/TA \qquad (3)$$

Log-Likelihood	-19.885
Restricted Log-L	-24.953
Chi-square(1)	10.136
Significance	.00145

C/TA had a t-ratio of -2.438, which is significant at the 1.5% level. The chi-square statistic is significant at the 5% level.

Discriminant Analysis. The SAS statistical package was used to perform the discriminant analysis. Since the procedure assumes a multivariate normal distribution within each class, variables that were shown as not being from a normal population were excluded. Initially, three different stepwise discriminant analysis procedures were used--forward, backward, and stepwise selection. The accuracy rates for models with various combinations of the ratios ranged from 61.1 to 63.9 percent. Subsequently, ratios that were shown to be unexpectedly larger for the bankrupt sample versus the nonbankrupt sample were deleted. Models developed using combinations of these ratios had accuracy rates ranging from 55.6 to 69.4%.

Because of the success of the C/TA ratio in the univariate logit regression model, this ratio was tested in the discriminant analysis models and found to be the best predictor with an overall accuracy of 77.8%. The univariate linear discriminant function was:

$$Z_i = -.51464 + 5.49922\ C/TA \qquad (4)$$

The coefficients cannot be tested for significance as they were in logit analysis. Several measures have been proposed to determine the relative importance of individual variables, but none of these has proven to be particularly successful [4:883].

Table V shows the Z-scores for the 36 companies. Assuming a 50% prior probability of being chosen from either the bankrupt or nonbankrupt population, any company with a Z-score below zero is classified bankrupt, and otherwise as nonbankrupt. With prior probabilities of 50%, the prediction accuracy rates are 88.9% for bankrupt firms, and 66.7% for nonbankrupt firms.

Based on the Lachenbruch procedure, the model's overall error rate was determined to be 25 percent. Although the Lachenbruch procedure is recommended with small samples, the procedure does not adjust for prior probabilities and misclassification costs. Accordingly, this error rate is too optimistic.

Adjustments. The actual proportion of

TABLE V

Z-SCORE CLASSIFICATION ACCURACY RATES

			Classifications (B=Bankrupt;NB=Nonbankrupt)		
	Prior probability:		.50/.50	.03/0.97	.03/0.97
	Cost classification:		1 to 1	1 to 1	5 to 1
Status	C/TA	Z-score*			
NB	0.024	-0.383	NB	NB	NB
NB	0.034	-0.328	NB	NB	NB
NB	0.029	-0.355	NB	NB	NB
NB	0.017	-0.421	NB	NB	NB
NB	0.010	-0.460	NB	NB	NB
NB	0.142	0.266	B	NB	NB
NB	0.017	-0.421	NB	NB	NB
NB	0.035	-0.322	NB	NB	NB
NB	0.010	-0.460	NB	NB	NB
NB	0.000	-0.515	NB	NB	NB
NB	0.044	-0.273	NB	NB	NB
NB	0.228	0.739	B	NB	NB
NB	0.006	-0.482	NB	NB	NB
NB	0.004	-0.493	NB	NB	NB
NB	0.072	-0.119	NB	NB	NB
NB	0.023	-0.388	NB	NB	NB
NB	0.014	-0.438	NB	NB	NB
NB	0.011	-0.454	NB	NB	NB
Accuracy Rates (%)			89.89	0.00	0.00
B	0.120	0.145	B	NB	NB
B	0.271	0.976	B	NB	NB
B	0.027	-0.366	NB	NB	NB
B	0.157	0.349	B	NB	NB
B	0.097	0.019	B	NB	NB
B	0.985	4.902	B	NB	NB
B	0.098	0.024	B	NB	NB
B	0.015	-0.432	NB	NB	NB
B	0.036	-0.317	NB	NB	NB
B	0.096	0.013	B	NB	NB
B	0.154	0.332	B	NB	NB
B	0.100	0.035	B	NB	NB
B	0.100	0.035	B	NB	NB
B	0.079	-0.080	NB	NB	NB
B	0.169	0.415	B	NB	NB
B	0.005	-0.487	NB	NB	NB
B	0.064	-0.163	NB	NB	NB
B	0.208	0.629	B	NB	NB
Accuracy Rates (%)			66.67	100.00	100.00
Overall accuracy rates (%)			77.78	50.00	50.00

* Z-score = -.51464 + 5.49922 C/TA

bankrupt to nonbankrupt companies in the population is certainly different than .5/.5. Zavgren has estimated the proportion to be .03/.97. In addition, the cost of prediction errors are clearly not equal. Adjustments are thus necessary to more correctly state the predictive accuracy of the model.

Kleinbaum *et al.* [5:27] suggest that $\ln(p_1/p_2)$ can be used to derive a new cutoff point taking the different probabilities into consideration, where p_1 is the probability of being in the bankrupt population and p_2 the probability of being in the nonbankrupt population. Using Zavgren's estimate, $\ln(.03/.97) = -3.476$ was used as the cutoff point to adjust for prior probabilities. As can be seen in the Table V, the adjusted cutoff point classified 0% of the companies as bankrupt and 100% as nonbankrupt, for an overall accuracy rate of 50%. Clearly, the model is now no longer any better than a naive model that predicts all companies as being nonbankrupt.

Misclassification costs should also be considered. In this model it would be more costly to the government to misclassify a bankrupt company as nonbankrupt than vice versa. The cutoff point is adjusted for misclassification costs by $\ln(c_{12}/c_{21})$, where c_{12} equals the cost of misclassifying a bankrupt firm as nonbankrupt, and c_{21} equals the cost of misclassifying a nonbankrupt company as bankrupt [5:28].

While the actual misclassification costs are unknown, a ratio of $c_{12}/c_{21} = 5/1$ seemed reasonable, where the cost of misclassifying a bankrupt firm as nonbankrupt is five times more expensive than vice versa. When the effects of oversampling and misclassification costs were combined the predictive accuracy remained 0% for the bankrupt sample and 100% for the nonbankrupt sample.

CONCLUSION

Four financial distress models were evaluated using financial ratios from failed government contractors. Two of the models were developed from a generalized database and two were developed using data from the defense contractor industry. None of the models, including the one used by the Defense Contract Audit Agency, could discriminate between bankrupt and nonbankrupt companies with accuracy rates close to those originally reported. Problems involving the oversampling of bankrupt firms, the nonstationarity of collinear ratios, and unequal misclassification costs probably contributed to the substantially reduced accuracy rates. Therefore, the apparent error rates originally reported by these models cannot be expected to represent the error rates encountered in application.

Two techniques, logit and multidiscriminant analysis, were used to build models based on the sample data. Both yielded a univariate model with C/TA as the predictor variable. Based on the estimation sample, the prediction accuracy was 78 percent (an apparent error rate of 22 percent). Using Lachenbruch's validation procedure, the overall error rate was 25 percent. However, after adjusting for estimated prior probabilities and misclassification costs, the model could do no better than a naive model that classifies all companies as nonbankrupt.

In order to develop a reliable financial distress model for the defense contract industry, several extensions are suggested. First, a clearer definition of financial distress is needed. Operationalizing the financial distress variable as firms that file for bankruptcy is a gross oversimplification. Firms may file for

bankruptcy for reasons other than financial difficulties. Second, the use of variables in addition to financial ratios is desirable. For example, capital market studies have demonstrated the information content of stock returns and macroeconomic indicators. Third, a larger database is needed. Locating financial data on just the 18 bankrupt companies used in this study was extremely difficult. Finally, data revealing the cost of financial distress to the government, and the proportion of distressed versus nondistressed firms are needed to properly state the model's error rate.

While the difficulty and cost of gathering such data may be high, the expected payback from reliably predicting financially distressed contractors is enormous. It will always be important to identify ways to more efficiently manage defense expenditures. Research to identify a reliable financial distress model specific to the defense contract industry should continue.

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The Advanced Amphibious Assault (AAA) Risk Management Program: Early Emphasis on the Reduction of Future Operating and Support (O&S) Resource Requirements

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Abstract

One of the challenges of any acquisition program is to achieve the best possible balance between cost, performance, and program schedule. Early estimation of future operating and support (O&S) costs is part of the challenge so that affordability judgements can proactively influence a weapon system's design. However, historically, it has been difficult, if not impossible, to identify and act upon major O&S cost drivers during the early concept phase. As a consequence, designers make key decisions, usually based upon engineering concerns, that profoundly affect the long term cost of ownership of a weapon system without knowing the implications of their choices. Thus O&S requirements have become the unaltered by-products of initial engineering decisions. The resulting conclusion is that very little can be done about the price of ownership of a weapon system. If this process is not challenged, the prospect of finding ourselves with a major weapon system which we are able to develop, but not able to own, is real and grows in proportion to weapon system complexity. This paper describes one promising technique for reducing O&S costs early in the acquisition process.

In addressing this problem, the government directed that the design of the Advanced Assault Amphibian Vehicle (AAAV) be the product of a design to ownership process. The purpose of this paper is to explain this design to ownership process and to present some preliminary findings. The lessons learned from this acquisition should apply to future procurements.

Introduction

This paper documents the risk management approach being used to reduce future operating and support (O&S) resource requirements for the Advanced Amphibious Assault (AAA) program.

In order to fully understand the design and support issues associated with the AAA program, the Over-The-Horizon (OTH) Concept of amphibious operations will be addressed first since this challenge generates the most complex design parameters of the weapon system. Next, the risk reduction approach used to manage affordability and supportability will be described.

The Over-The-Horizon (OTH) Challenge and Design Performance Parameters

The emphasis on maritime strategy and power projection from the sea will continue to focus the Marine Corps on maintaining expeditionary, quick-hitting forces capable of conducting amphibious operations at all levels of conflict. The requirement to maintain a forcible entry assault capability is vital to maritime power projection. During the 2000-2020 time period, amphibious assault will remain the principal means of power projection onto a hostile shore.

The evolution of the OTH amphibious operation, as indicated by Table I, reflects the Navy's realization that its ships are vulnerable to surface-to-surface and air-to-surface weapons systems along with the difficulties presented by shallow water mines.

Table I
Over-The-Horizon (OTH) Concept

- Protects the Amphibious Task Force (ATF)
  - From Direct Fire
  - From Visual Observation
- Maintains ATF Under Striking Fleet Umbrella
- Deceives Enemy as to Tactical Intention
- Permits Retention of U.S. Maritime Forcible Entry Capability.

Extending ship operating areas beyond the visual horizon improves the survivability of the ships and increases the opportunity for tactical surprise due to the uncertainty generated by operations conducted in proximity to the enemy, but beyond his direct observation. The mobility inherent in amphibious ships, combined with the extended standoff distance, enables the Amphibious Task Force to threaten an expanded coastline thereby diluting the enemy defenses as to which one of many potential landing sites will be utilized.

The Advanced Assault Amphibian Vehicle (AAAV) Concept

Up to now, amphibious warfare tactics had not radically changed since World War II. However, OTH tactics represent a distinct departure from past methods. Of all the potential solutions being considered for the OTH challenge, the one which has generated the most visibility, both inside and outside the Marine Corps, is the self-deploying, high-speed amphibious vehicle. This specific project within the Advanced Amphibious Assault (AAA) Program, commonly referred to as the Advanced Assault Amphibian Vehicle (AAAV), is arguably the highest payoff candidate system being considered, and constitutes an ambitious step in technology. The mission designated for the AAAV is summarized by Table II.

Table II
AAAV Mission

- Provide High Speed Transport of Marine Assault Forces from Amphibious Ships Located Over-The-Horizon to Inland Objectives
- Provide Armor Protected Land Mobility and Direct Fire Support to Embarked Marine Infantry during Combat Operations Ashore

The AAAV is certainly one of the more technically challenging options and the one that has, comparatively speaking, the least amount of empirical data readily at hand. Table III presents an overview of the schedule.

Table III
AAA Program Schedule

Milestones	90-91	92-96	97-00	01-06
Concept Exploration	—			
Demonstration & Validation		—		
Full Scale Development			—	
Production and Fielding				—
Initial Operating Capability (IOC)				△
Full Operating Capability (FOC)				△

Unlike tanks and artillery where changes in technology and employment have proceeded in a steady and measured pace over the past 45 years, the new amphibious vehicle requirement (as presented by Table IV), coupled with OTH tactics, constitutes a rather bold step.

Table IV
System Operational Requirements

- Water Speed Greater than 20 Knots
- Land Speed Equal to the Main Battle Tank of the Time Frame
- Carry a Reinforced Rifle Squad (18 Marines)
- Armor Protection against Automatic Weapons, AP Mines, and Artillery Fragments
- Offensive Firepower to Defeat All Light Armored Vehicles of the Time Frame

The Advanced Assault Amphibian Vehicle (AAAV) & Program Risk

Soon after Milestone 0, the AAAV project team discussed many issues but the principle focus centered upon:

o the limitations placed upon AAAV concept development by the eternal triangle: cost, schedule, and performance,

o and other external factors which could impact cost, schedule, and performance.

These "other" external factors were most often circumstances related to the project which, if left unattended, had the potential for disrupting one of the elements of the triangle. In other words, these factors could cause something negative to happen within the program. These "other" factors are commonly referred to as "risks." A listing of key O&S factors evaluated as contributing to program risk are presented in Table V.

Table V
O&S Factors Influencing the AAA Requirement

- Force Level Reductions are a Certainty
- Lessons Learned from the "Tech Base" Showed a High Probability of Greater Technical Complexity
- Maintenance of the Current System is Currently Taxing the Logistics and Training Support System
- "New" Systems do not Necessarily eliminate "Old" Problems
- Long Term Trends in Defense Spending will Increase the Emphasis on the Cost of Ownership

The Initiation of the AAAV O&S Risk Reduction Program

The preliminary conclusion made from management's assessment of operational risks was that an O&S risk reduction approach should be developed. The selected approach required that predecessor and comparable system operating and support (O&S) lessons learned would be used to reduce the AAAV's development risk. This is because the common thread which linked management's concerns were potential risks associated with affordability, supportability, manpower, personnel, training, human factors, safety, and health hazard issues. Problems in these areas could negatively impact all parts of the "triangle" and would also result in increased life cycle cost and possible operational performance degradation.

The key to eliminating these potential risks was to find a way to factor "lessons learned" into the design process to ensure an affordable design for the user's environment. Management's interpretation of the challenge was the need to translate past O&S problems into new engineering solutions. Decisions made to support this

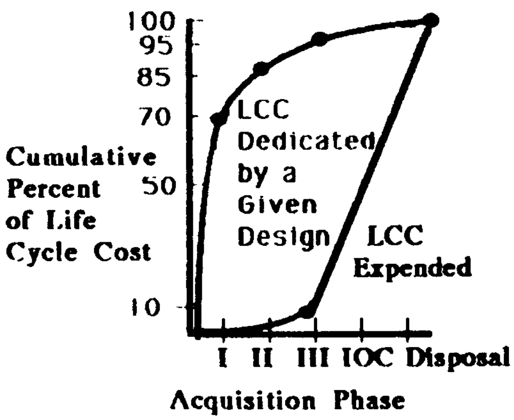
risk management strategy include two key elements:

o Declare the use of integrated front end analysis as a risk management technique and view it from that perspective at the Program Office level and

o Assess the affordability and supportability risk with iterative O&S cost projections throughout the development process.

Once the overall strategy was developed, there was the further question of when and how to implement the specifics of the program. Lessons learned from past acquisitions indicate that the management of a systems affordability and supportability should begin as soon as possible. Table VI represents: (a) the percent of a typical program's life cycle cost (LCC) dedicated per phase (e.g., left arc) and (b) the percent of LCC actually expended per phase (e.g., right arc). The table indicates that less than 10 % of a program's LCC is expended during Phase I & Phase II. However, design decisions made during Phase I determine approximately 70% of a weapon system's LCC. The question was no longer <u>when</u> to impact design, but <u>how</u> it would be accomplished during Phase I.

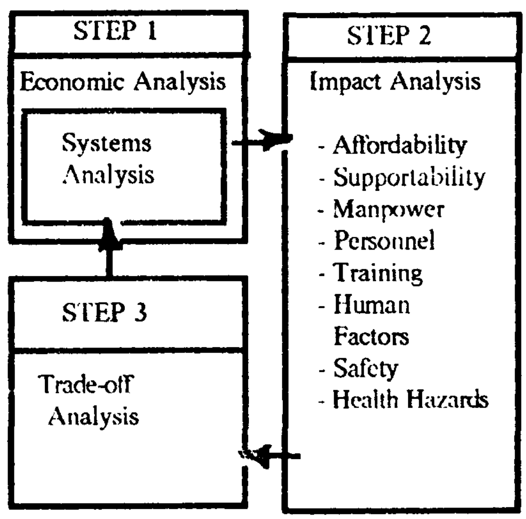
Table VI [1]
Life Cycle Cost (LCC) Dedicated And Expended Per Acquisition Phase



The Selected Risk Management Process: Engineering and Supportability Analysis Integrated by Economic Modeling

A goal of the program's risk management plan was to ensure that the design and development of the new weapon fit the total affordability and supportability constraints of the Marine Corps. As indicated by Table VII, a new system's design has to be assessed with regard to affordability, supportability, manpower, personnel, training, human factors, safety and health hazards. In the past there have been problems integrating logistics and manpower, personnel, training, and safety (MPTS) comparability analyses into the system design process because of the cumbersome and time consuming nature of the required analyses.

Table VII
The Selected Front End Process:



The selected AAAV risk management solution requires the use of a documented, design influencing process to minimize O&S resource requirements. The approach utilizes a streamlined version of comparability analysis and the use of an economic model to project the system requirement in terms of operating and

support impacts. A summary of the iterative steps in the process includes:

Step 1: Develop an economic model of the baseline system concurrently with the new system's requirements analysis.

Step 2: Analyze the impact of past designs, and propose preliminary design solutions.

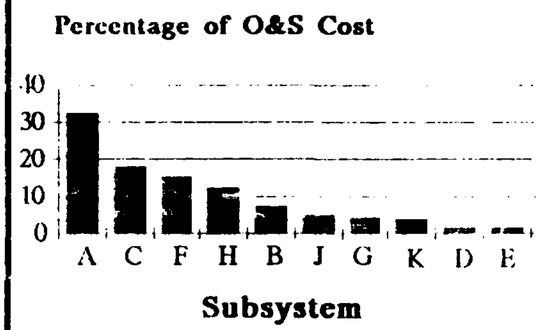
Step 3: Use the economic model as a tool for trade-off analysis.

The process was developed to integrate the requirements of DoD Directive 5000.53, Manpower, Personnel, Training and Safety in the Defense Systems Acquisition Process; DoD Instruction 5000.2, the draft Defense Acquisition Program Procedures; OPNAVINST 5311.7 (Series) The HARDMAN Process; and MIL-STD-1388-1A, Logistic Support Analysis. Each step in the process will be further described.

Step 1: Develop an economic model of the baseline system concurrently with the new system's requirements analysis.

The initial objective of the economic modeling is to identify past O&S problem areas or "high drivers." For the AAAV Program, the economic model selected was the Equipment Designers Cost Analysis System (EDCAS). Design contractors were required to model a baseline system as a basis for comparison. The required comparability analysis identifies key problem areas to target for design emphasis. Table VIII represents a typical graph developed in response to this requirement to identify "high driver" subsystems. It represents the type of historical projections required to show which subsystems have driven O&S costs in the past.

Table VIII
Identification of Baseline High Driver Subsystems



As previously described, the economic modeling proceeds concurrently with the system requirements analysis which includes the new system requirements derivation and the supportability and MPTS comparability analysis. Table IX indicates a summary of supportability and MPTS problems to be resolved based on an analysis of predecessor and comparable system problems.

Table IX
Baseline Problems

Logistics
- Number of tools required
- Amount of test equipment
- Time required to access damaged equipment

Manpower
- Number of people required

Personnel
- Skill levels required

Training
- Sustainment of troubleshooting skills
- Sustainment of gunnery skills

Human Factors
- Complexity of turret procedures
- Visibility limited when buttoned up

Safety
- Malfunction of heater
- Limitation in safety crash padding

Health Hazards
- Exhaust fumes

In the implementation of this analysis in the AAAV Project, approximately 30 lessons learned reports were provided as government furnished information (GFI) for industry's evaluation. Industry's requirement as directed by three HARDMAN Assessment Data Item Descriptions (DIDs) and a HARDMAN/Logistics Supplement to the AAAV Request for Proposal, was to conduct an AAAV requirements analysis with concurrent and interdependent engineering, logistics, and MPTS front end analyses. The economic model was required as a bridge between engineering design requirements and logistics/MPTS resource impacts. A summary of the use of the economic model includes:

o first model baseline and later notional vehicle subsystems (e.g., COMM/NAV, Fire Control, Propulsion, etc.);

o perform sensitivity analysis on input parameters to identify "high drivers" or other areas of concern;

o relate "high drivers" to predecessor system operations and support (O&S) problems;

o as clear subsystem and equipment alternatives emerge, use the economic model to conduct trade-off analyses of alternative subsystem designs.

It should be stressed that the process starts with "rough data" or "best guesses." If the analysis is delayed for the collection of highly reliable data, the new system design will not be influenced until Acquisition Phase III. As previously indicated by Table VI, there is a minimal opportunity during Phase III to impact life cycle costs because the major design decisions have been made during Phase I.

Step 2: Analyze the impact of past designs, and propose preliminary design solutions.

For the AAAV Program, industry's requirement was to analyze past user problems and to develop measurable design solutions. First the predecessor or comparable system problems are listed with an identification of potential design solutions. As indicated by Table X, the past requirement for an excessive amount of tools could be reduced by requiring standard connectors in the new design. In this case, the requirement for a design to use "no more than seven tools" is a proposed design rule for further evaluation. If this design rule adversely impacts the feasibility of the engineering concept, then an economic analysis can be run to support a decision on this design rule. The primary product of this step is an audit trail of past problems and potential solutions for incorporation into the new design.

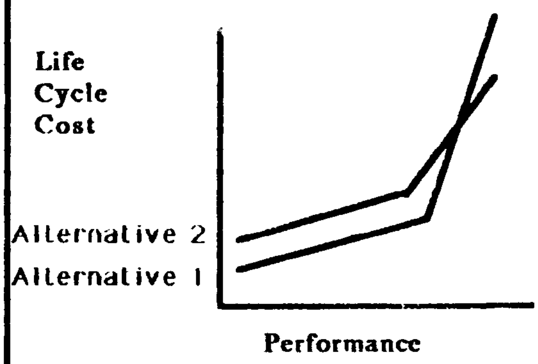
Table X
Impact Analysis Format

Problem	Potential Solution	Design Feature	Design Rule	Trade-off
Logistics Too many Tools	Eliminate Special Tools	Standard Connector	Design for Seven Tools	Unit Cost vs O&S Cost
Manpower				
Personnel				
Training				
Human Factors				
Safety				
Health Hazzards				

Step 3: Use the economic model as a tool for trade-off analysis.

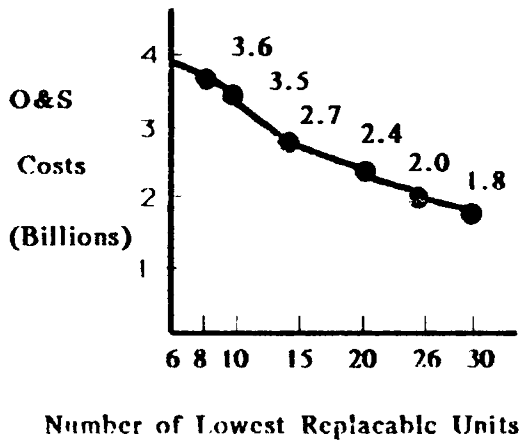
Industry's requirement was to analyze design decisions considering their life cycle impact. As indicated by Table XI, an increase in performance generally translates to an increase in life cycle cost. Given the intense mission requirements of today's combat environment, new system designs will most often need to be optimized for performance. However, given several competing design concepts, the program manager must know the relative difference in life cycle requirements. In the case of the AAAV Program, O&S impacts have influenced several key design decisions through the use of this type of analysis. In some cases, the least expensive support requirement was selected. In other cases, a preliminary decision for the high performance subsystem concept was selected for the demonstration/validation phase with the intention to reconsider the lower LCC alternative during the next phase when its technology matures.

Table XI
Sensitivity Analysis of Two Concepts



After selection of notional subsystems, designers were required to run additional sensitivity analyses and partitioning analysis. The sensitivity analyses were to determine the relative life cycle impact of improving a potential design problem. The partitioning analyses were required to determine the optimal economic design for supportability. Table XII illustrates the potential life cycle savings from proper partitioning. In this example, a rough order of magnitude savings of a billion dollars was saved in a Martin Marietta design (Daugherty, G., 1989)

Table XII [2]
Partitioning Analysis Graph



Conclusion

Even though the AAAV Program is still in the Concept Exploration Phase, the front end analysis process is focusing the designers' attention on operating and support (O&S) issues. Key design decisions have been impacted by O&S considerations, and it is projected that there will be a significant reduction in the number of intermediate maintenance personnel. The program is still in the stage of completion of trade-off analysis with partitioning analysis yet to be completed. The purpose of this paper was to explain the AAAV Risk Reduction Process. It is the intention that a following paper will provide more detail when the notational design approaches are determined.

Endnotes

1/ See Department of the Navy. (1988, January) Acquisition Streamlining Course Notebook (Specification Control Advocate General of the Navy). Graph is from Section I of the notebook.

2/ See Daugherty, G. L., (1989, August) Contracting for Supportability and Affordability (Proceedings 1989 Annual Reliability and Maintainability Symposium). Graph presented is summarized version of one on page 471 of the proceedings.

USING TECHNICAL PERFORMANCE MEASUREMENT AS A BASIS FOR SATISFYING EVENT DRIVEN MILESTONE TECHNICAL EXIT CRITERIA

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ABSTRACT

The Army's Anti-Satellite (ASAT) Joint Program Office (JPO) embarked in August 1990 on the Demonstration/Validation phase of a Kinetic Energy ASAT Weapon System acquisition program. The program is on a success oriented schedule subject to very specific, event driven Milestone I exit criteria. A Technical Performance Measurement (TPM) Program has been established by the ASAT JPO in accordance with MIL-STD-499A and FM 770-78 that will be used as the basis for satisfying the majority of the performance and readiness/supportability elements of the exit criteria. Examples of exit criteria performance parameters to be satisfied by TPM are: engageable altitudes, missile range/altitude, targets/engageable rate, system effectiveness, single shot kill probability, survivability, system reliability, availability, and maintainability. This paper reviews current management tools available and provides an integrated approach to cost/schedule and performance management.

The Work Breakdown Structure (WBS) is useful to program managers for technical, schedule, and financial control of the program. The Cost/Schedule Control System Criteria (C/SCSC) requires that work progress be quantified through "earned value," an objective measure of how work has been accomplished on the contract, and allows comparisons to be made against the plan which identifies schedule and cost variance. The Schedule Network correlates the TPM and the WBS through earned value techniques. Finally, the TPMs assure that potential performance deficiencies are identified before they result in significant cost or schedule impact, and allow time for establishment of alternative paths for solution of potential problems. A quadrilateral reporting method has been derived that ties the WBS to the TPMs using a composite WBS. The paper proposes a coding system that relates the work elements to a given TPM.

INTRODUCTION

A program manager must be cognizant of three basic program elements: cost, schedule, and technical performance. The first two are tracked through control systems such as C/SCSC and networks. Technical performance is tracked through the Technical Performance Measurement system.

Work Breakdown Structure. A Total Quality Management (TQM) initiative on Cost/Schedule Management Processes was started at the 1989 C/SCSC National Workshop. A very systematic/scientific approach was invoked by the TQM steering committee to research and collect data. The data base included team (industry and government) interviews with over 60 government programs, twelve different companies, and over 3,600 comments from questionnaires. The consensus of the data revealed strong concern in six major areas. Work Breakdown Structure was either directly or indirectly , a contributor to all six areas of concern. In fact the WBS was the number one major concern of both government and industry.

The traditional Work Breakdown Structure is designed to ensure accurate control of all work on a project without having overlap between WBS elements. It covers all activity from early development activities through production and delivery of the final hardware and software. To cover this spectrum of activities the WBS is normally broken down by end items and activities. The activities include engineering, test, and logistics as well as management . End items include both prime mission equipment, such as aircraft, missiles, etc., and support and training

equipment.

The Work Breakdown Structure in its several forms is an extremely useful device as program managers engage in planning and controlling their programs. A WBS, if sufficiently written, defines the program's total objectives; it relates the various work efforts (parts) to the overall product (whole). The WBS is the foundation for:

-- Program and technical planning
-- Cost estimation and budget formulation.
-- Schedule definition.
-- Statements of work and specification of contract line items.
-- Progress status reporting and problem analysis.

The WBS is essential in providing the capability for a program management office to exercise technical, schedule, and financial control of the program. Related performance measurement systems include the Cost/Schedule Control System Criteria, Cost/Schedule Status Report, Cost Performance Report, Milestone Measurement/Cost Correlation, and Technical Performance Measurement .

Cost/Schedule Control System Criteria. Department of Defense (DOD) has adopted an approach to identify general criteria that contractor management control systems must meet. Use of the criteria must be based upon common sense and practical interpretations that maintain the capabilities for adequate performance measurement. Uniform implementation of the criteria avoids imposing multiple cost and schedule systems on the contractors. Application of management control systems acceptable to the government and contractor will provide a common source of information for all management levels.

The objectives of C/SCSC are twofold:

-- For contractors to use effective internal cost and schedule management systems
-- To provide the government with timely and auditable data produced by those systems for determining product-oriented contract status.

The C/SCSC improves on the budget verses actuals management technique by requiring that work progress be quantified through "earned value," an objective measure of how work has been accomplished on the contract. As work is accomplished, the earned value concept allows comparisons to be made against the plan which identifies schedule and cost variance.

In order to ensure consistency between reporting systems the C/SCSC uses the WBS as the primary structure for cost and schedule reporting for both internal and government management of the project. The WBS breaks a project down into small manageable components and defines them by delegating responsibility for individual work packages.

Network. The complex nature of a program demands that planning of what has to be done and the schedule for performance must be done together to create a schedule network. The program manager must determine the activities required, the timing, the resources and the their interdependence as it relates to program completion. The Program Master Schedule provides a complete picture of all program activities related to major program milestones. Subtiered schedules are networked together to develop the master schedule.

Scheduling systems are event driven. They can be correlated to the TPM and the WBS through earned value technique schedules similar to the techniques used in C/SCSC. There are problems in correctly interpreting success, i.e. a test occurred but did the results of the test meet the required performance?

Technical Performance Measurement. Use of TPMs assures that potential performance deficiencies are identified before they result in significant cost or schedule impact. TPMs also support risk abatement activities by allowing time for establishment of alternative development paths for solution of potential problems. The TPM process of continuing program reviews ensures that technical performance parameters, selected from the requirement/performance matrix for tracking, focus management attention on a

meaningful set of parameters which meet specific selection criteria:

-- They must be measurable
-- They must have an uncertainty
-- They must have a potential for impacting the program.

TPM takes selected critical product elements of the contract WBS and provides a method of monitoring their technical status throughout the program.

The problem of integrating the Technical Performance Measures with the WBS is that the performance of systems does not readily devolve by final end item, but is dependent upon the performance of several end items. For example, the accuracy of a rifle is dependent upon both the rifle and the ammunition. A rifle with good mechanical design, i.e. stock, chamber, barrel, etc cannot produce accurate hits with inferior ammunition that has large variability from round to round. An accurate TPM would include both the rifle and ammunition but a traditional WBS would break out the work of designing and manufacturing each item separately. There is no easy method combining and correlating the work of designing and manufacturing each component, or of evaluating the cost of meeting a given accuracy.

METHODOLOGY

In attempting to correlate the WBS, schedule systems and the TPMs several methods were explored. First , an alternate WBS was examined that would explicitly track the key performance measures, so that the WBS might include an element such as rifle/ammunition performance. In trying to develop such a system it became apparent that the resulting WBS would lose the ability to track the cost of deliverable end items. This is a key cost control element during production since many end items are procured under separate contracts, either as subcontracts by the prime or as separate contracts by the government. It was felt that loss of this cost visibility was too high a price for TPM traceability.

A second alternative is to force a TPM structure that matches the WBS to ensure traceability. This approach is practical for many performance measures that are primarily controlled by the performance of an individual subsystem. In this case the work related to meeting a given performance level can be tracked through the design and manufacture of the particular component. This appears to be an attractive method of using TPMs as systems move from development into production. As this occurs the parameters that affect a TPM can be allocated to end item much as reliability, weight , etc., are allocated during design. Further study needs to be done in this area to develop methods to properly allocate the TPM during finalization of the design and production start up. However this allocation method does not appear attractive during early development where the basic division of the system into subsystems has not yet been decided.

In the early stages of program development the TPMs will most probably overlap several traditional WBS elements such as systems engineering, test, etc. The most promising method of integrating TPMs into the traditional structure lies in tracking the cost, schedule and performance information in a manner that highlights any discrepancies between the reporting systems. We have therefore concentrated on developing a system to correlate elements of the C/SCSC, the Network Schedule Control System, and the TPMs.

Composite Work Breakdown Structure. A "composite WBS" was developed that reflected the cost/schedule information for most of the work supporting a particular TPM. This composite would not be a standard "roll up" by WBS but would combine lower level WBSs from several areas to reflect the status of the TPM. For example, the composite WBS might combine lower level WBSs from the missile, systems engineering and test that contribute to the Kill Vehicle (KV) weight evaluation. Reporting of this composite WBS should reflect the cost of work planned, actuals to date and projected cost to completion.

Two methods were examined to develop the composite WBS for a TPM. The program management office could do a "one time" evaluation of each critical TPM, to determine those WBS elements that constitute the bulk of the effort for the TPM. These could then be reported and tracked each month. This would be relatively easy to set up but would be incomplete and might miss important WBS elements that did not contribute to a TPM at the beginning of the program but did later.

Alternately, an alphacode could be included in the cost /schedule data base for each WBS element to identify which TPMs it supported. This would be more work to implement than the first approach but the monthly tabulation would be more efficient and the composite WBS more complete. This was the recommended method.

TPM Reporting Format. A reporting format that combines the elements of the C/SCSC, the Network Schedule Control System, and the TPMs was developed. The critical TPMs would be reported in a "quad chart" format combining elements already being reported in different formats.

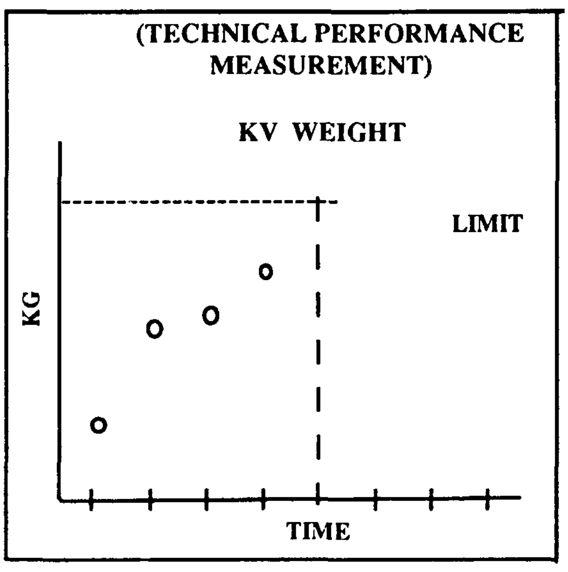


TABLE 1

Table 1: TECHNICAL PERFORMANCE MEASUREMENT. The TPM indicator(s) are reported along a time scale. This reflects the TPM status, for example KV Weight, over time which is already part of the TPM tracking system.

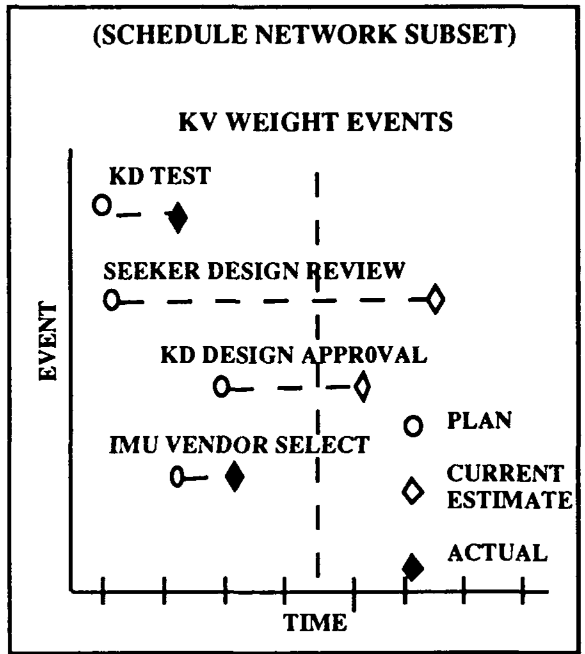


TABLE 2

Table 2: SCHEDULE. This presents a subset of the network schedule as it related to the particular TPM for the same time scale as block one. It shows the events that are related to the TPM. Slippages as well as accomplishments for the TPM are shown.

(ACCOMPLISHMENTS/SPECIFIC PLANS)
KV WEIGHT ACTIVITIES

ACCOMPLISHMENTS:

- **CONDUCT STUDY OF MAGNESIUM STRUCTURE**

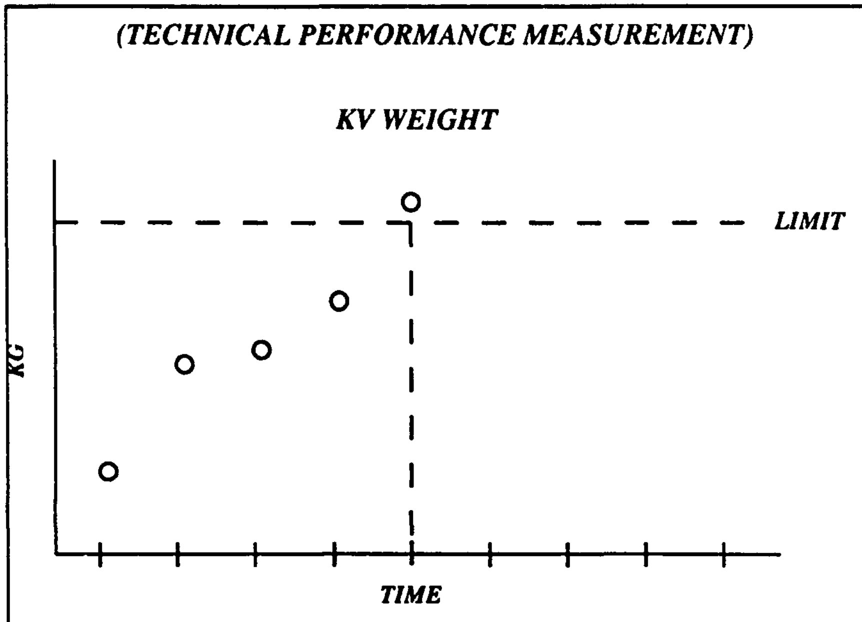
SPECIFIC PLANS:

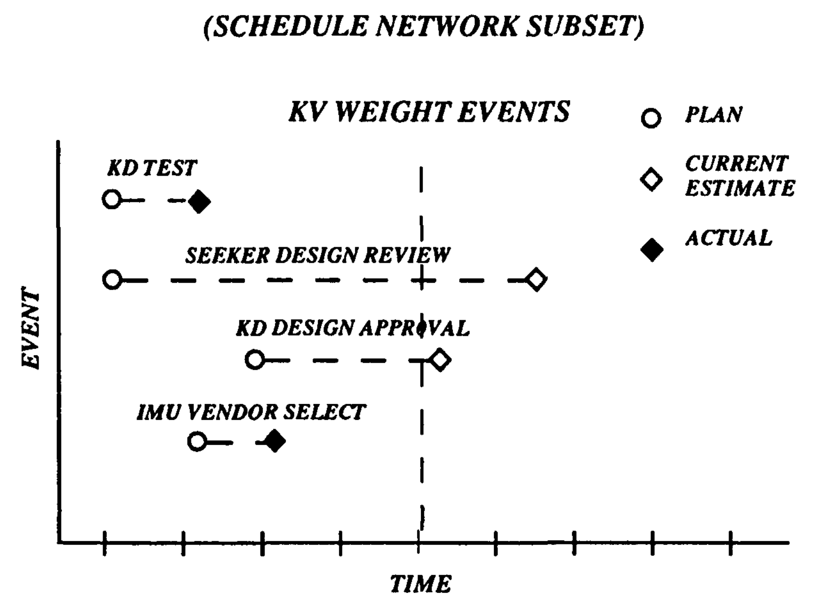
- **APPROVE KD DESIGN/WEIGHT**
- **REVIEW VENDOR PROPOSALS**
- **REDESIGN ALPHA BOX** — **NEW ITEM**

TABLE 3

TABLE 5

(EXAMPLE) TPM - KV WEIGHT (EXAMPLE)





(ACCOMPLISHMENTS/SPECIFIC PLANS)
KV WEIGHT ACTIVITIES

ACCOMPLISHMENTS:

- ***CONDUCT STUDY OF MAGNESIUM STRUCTURE***

SPECIFIC PLANS:

- ***APPROVE KD DESIGN/WEIGHT***
- ***REVIEW SEEKER VENDOR PROPOSALS***
- ***REDESIGN ALPHA BOX*** — NEW ITEM

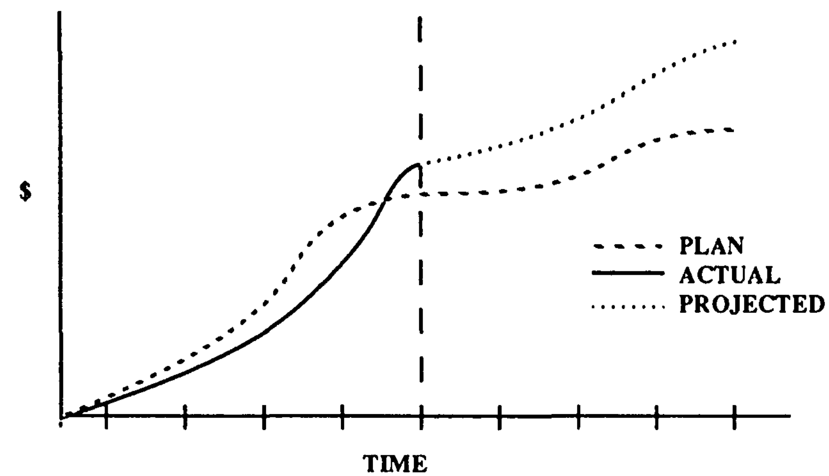


Table 3: PLANS/ACCOMPLISHMENTS. This shows the contractor's specific accomplishments and plans relating to the particular TPM, for the reporting and upcoming month. Any changes to the planned work would be highlighted. For example, if the TPM were KV weight and the contractor decided to redesign a component to reduce weight and keep the TPM within bounds, the added redesign task would be included here.

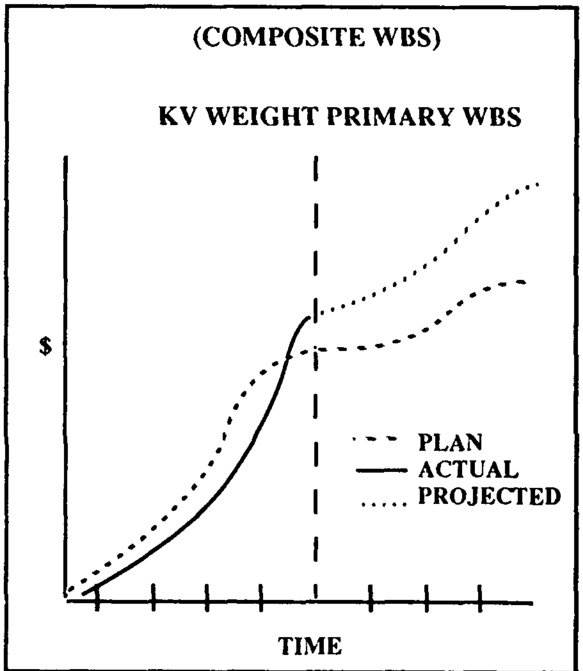


TABLE 4

Table 4: COMPOSITE WBS. This reflects the cost/schedule for the composite WBS for the TPM. This block would show the cost of work planned, actuals to date and projected cost to completion. The monthly reporting of this composite WBS should reflect the schedule changes and any actions or accomplishments reported in the other blocks. For example a new redesign task in block 3 should show a change in cost and schedule to complete in block 4. A slippage of a test in block 2 should also show up here.

TABLE 5: QUAD CHART. The combination of these four blocks presents a complete picture of a TPM. A realistic evaluation by management will give a realistic picture of each critical TPM. An overly optimistic evaluation will be obvious in one of the four blocks. If all blocks show the TPM within limits, on schedule, and within cost then the program manager can have confidence the TPM is being met. But if, for example, block 2 shows a schedule slip without changes in projected expenditures in block 4, or the TPM is out of bounds without corrective actions in block 3, then the area should be investigated for problems.

The combination of these four areas allows for traceability between TPMs, the network system, and the cost/schedule performance as reported through the WBS structure.

SUMMARY

The Army's Anti-Satellite Joint Program Office is on a success oriented schedule subject to very specific, event driven Milestone I Exit Criteria. The ASAT Technical Performance Measurement Program includes such exit criteria as engageable altitudes, missile range/altitude, and targets/engageable rate which are difficult to relate to traditional management control systems. We reviewed current management tools available and developed an integrated approach to cost/schedule and performance management. The approach integrated the Work Breakdown Structure, the C/SCSC and the Schedule Network with the TPMs using a composite WBS. We propose a coding system that relates the work elements to a given TPM and a presentation format to correlate the various management information systems for each TPM.

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RESEARCH, REFORMS,

and TRENDS

in ACQUISITION

COMPARISON OF RESULTS OF TWO CONSENSUS METHODOLOGIES WHEN APPLIED TO ISSUES OF DEFENSE ACQUISITION PROGRAM STABILITY

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ABSTRACT

Between November 1989 and June 1990, the Under Secretary of Defense (Acquisition) [USD(A)] acting through his Defense Acquisition Improvement Team sponsored a series of workshops to address issues and difficulties in Defense acquisition, and to generate solutions to the problems identified. One of the major issues examined was the problem of program stability.

Two different processes were used in the conduct of the workshops. This paper reports on the results of the workshops in the context of the different processes and concludes that the process used greatly influences the conclusions reached.

BACKGROUND

Historically, long periods of time have elapsed between the time a Defense acquisition program begins, and delivery of the hardware that program was to provide. Data indicate those times average between 10 and 12 years. During such long time periods many changes take place: the political, economic, and technological environments may even restructure.

To be successful, new product development programs will need to deal with change.

Within the Defense Acquisition community, problems of dealing adequately with change have been lumped under the general heading: "Program Stability Issues". Acquisition Program Managers have consistently voiced the desire for less "change" than they experience. Others involved in the acquisition process, while attempting to minimize change, recognize that in a 10-12 year period, there will undoubtedly be some.

In the past three years, incumbent USD(A)s have convened 2 different groups of almost all Defense and Service acquisition leaders to review broad spectrum of acquisition problems and attempt to derive solutions for them. Acquisition Leadership Conference 1988 (AL'88) was held in May 1988, and Acquisition Leadership Conference 1990 (AL'90) was held in April 1990. Conference objectives were to discuss and solve acquisition problems.

Issues discussed during these conferences were either specified by USD(A), or generated by the attendees. During preparation for AL'90, USD(A) asked acquisition leadership to identify current crucial issues. "Program stability" was one issue identified. It was discussed in 3 Nominal Group Technique (NGT) workshops in AL'90.

Separately from AL activities, USD(A) had also sponsored a series of DSMC workshops to explore issues of smart munitions acquisition improvement. "Program Stability" was among the issues raised in that effort.

Prior to completing preparations for AL-90, (and partly to provide input for AL-90 participants), DSMC was asked to convene a workshop to examine "Program Stability" issues. DSMC's Technical Manager's Advanced Workshops (TMAWs) use a process called "Interactive Management" (IM) developed by Professor John N. Warfield, George Mason University. Thus it happened that two different consensus methodologies (NGT and IM) were applied at different times, to the same issue.

THE PROCESSES AND METHODOLOGIES USED TO EXPLORE PROGRAM STABILITY ISSUES

Context of Application of Consensus Methodology #1 (NGT).

In early December 1989, the Under Secretary of Defense (Acquisition) (Mr. John Betti) began planning for a conference to discuss acquisition problems. DSMC was assigned the task of developing the conference. On 18 December 1989 DSMC's Commandant (MG Lynn Stevens) sent a concept paper to USD(A) outlining a procedure and modus operandus for two days of discussions. The concept included application of Nominal Group Technique methodologies in a number of simultaneous AL'90 workshops which would examine important issues within the Acquisition community.

To determine what those issues should be, a questionnaire was distributed to acquisition leaders/managers asking them to identify major problems which would be the subject of the AL'90 workshops.

Questionnaire responses generally grouped within 6 broad issues, all of which were discussed at AL'90 (held at Panama City, Florida during the period 2-3 April 1990). One identified issue was acquisition "program stability". The term was not specifically defined.

During the morning of 2 April 1990, three groups discussed "Program Stability" issues. Two of the groups consisted of 12 participants, the third group had 13 members. All participants were selected by the services or DoD. Nominal Group Technique (NGT) was applied in all workshops.

At the conclusion of the 3 morning workshops on "program stability", all group facilitators and one representative from each group met to consolidate the product of all 3 groups. The resulting synthesis of group deliberation on all 6 issues was presented to USD(A) and each of the three Service Acquisition Executives (SAE's) on the afternoon of 2 April 1990.

Because no integrated plan of action had been developed during AL-90, further discussion was needed about how to use the AL-90 product. DSMC held a one-day workshop on 16 May 1990 to review AL'90 results and to generate an organized plan to use it as a basis for resolving each of the six questions discussed.

On 25 May 1990, a final report of AL-90 recommended actions was sent to USD(A)'s Acquisition Improvement Team (AIT).

Context of Application of Consensus Methodology Case #2 (IM)

A special workshop using the Interactive Management process was held at DSMC on 14-15 March 1990, to

1. Define the term "Program Stability",

2. Discuss "manifestations of program instability" which create

problems for acquisition managers, and

3. Generate solutions (actions to be undertaken to reduce the severity of those problems).

DoD and the services selected 13 workshop participants who worked together during the workshop. All of them agreed to the final group products.

The Interactive Management Process (IM) was developed over a 20 year period by Professors John N. Warfield, Alexander N. Christakis and others at Batelle Memorial Institute, the University of Virginia, and finally George Mason University. The process as used in this workshop provided not only a way to focus group effort, but also, a way to derive relationships between parts of the problem.

The timeline of process application.

Figure 1 describes the time line of application for the two processes used. The significant differences between them is both in the time taken to apply the process and the way in which group members participated in it.

Figure 1

CONSENSUS METHODOLOGY APPLICATION PROCESS

Methodology #1 NOMINAL GROUP TECHNIQUE	*Application Timeline*	*Methodology #2 INTERACTIVE MANAGEMENT*
DSMC Commandant's Memo to USDA regarding AL'90	←18 December 1989	
AL'90 Questionnaire distributed	←-5 February 1990	
Formulation of AL'90 issues	←----1 March 1990	
	14-15 March 1990→	TMAW 90-3S Workshop
AL'90 held	←----2-3 April 1990	
Post AL'90 Focus Group	←-----6 April 1990	
Final AL'90 workshop	←-----16 May 1990	
Final AL'90 report sent to USD(A) Team	←-----25 May 1990	

PROCESS DIFFERENCES IN DETAIL

Differences in process application times.

Nominal Group Technique

NGT consensus methodology was applied successively by different facilitators to a serial set of workshops having different numbers of participants. 45 days elapsed between the first and the last workshops.

The first AL'90 workshops (two groups of 12 participants and one group of 13 participants) met for four hours on the morning of 2 April 1990.

The second AL'90 workshop met for 2 hours on the afternoon of 2 April 1990. This group had one member from each of the original 3 groups of participants. This group was referred to as AL-90 Issue Group #1.

The last workshop event (the second time Issue group #1 met) took place on 16 May 1990.

Interactive Management Technique

The IM consensus technique was applied over a continuous 2 days period. Participants in this group worked together throughout two 9 hour days.

Focus Question Generation Differences

Generation of NGT Focus Questions

AL'90 workshop questions were derived by consolidation of responses to a questionnaire. On 5 February 1990, each prospective AL'90 conference attendee was sent a questionnaire (see Figure 1) and asked to provide "ideas and concerns" which they believed should be discussed at AL'90. All survey responses were consolidated into a set of 6 "issue statements" by individuals who did not participate in the survey.

Fifty five problems derived from all questionnaire responses were grouped under the generic heading of "Program Stability". There were two questions asked of the participants of the three "Program Stability" groups:

The first AL-90 question was:

"What needs to be done to improve the program and related funding processes to improve program stability?"

Responses to this question suggested solutions to the issue. Each of the three workgroups generated sets of recommended actions independently.

The second AL-90 question was:

"What problems (barriers) are there in taking the actions (i.e., implementing the solutions) you have recommended?"

Generation of IM Focus Questions

A series of three questions was asked during the course of the workshop, and the discussion was procedurally focused at each stage through consolidation of ideas. Specifically:

The first question addressed to each group member was:

"Give your definition of 'Program Stability'".

After each member had provided their ideas, the group was asked to consolidate all of the ideas into a single definition.

The second question directed participants to focus on the group derived definition of program stability. The group was asked:

"What inhibits you from achieving program stability as defined by the group?"

After all ideas had been presented, the group selected the "most important" of them by voting. The 11 most important ideas served as a set of general problems within which all of the other ideas were clustered.

The third question focused group attention on developing mechanisms which would alleviate the problems contained within each of the 11 categories. The group was asked:

"What changes should be made to the acquisition process to alleviate the difficulties described in category #--"

Having generated a group of potential actions which would help resolve problems within each category, the group then selected the major single action which, if taken, would have greatest positive effect on the acquisition process.

DERIVING A FIRST ITERATION OF AN ACTION PLAN

AL'90 Work Groups

None of the individual groups focusing on "Program Stability" produced a workable implementation plan.

USD(A) had hoped that AL-90 would provide an implementable "action plan" for improving the acquisition process implement. No such product emerged. Although the three participants in AL'90 Issue Group #1 amalgamated all findings of Work Groups 1, 6, and 13 into a consolidated discussion topic, no action plan was derived.

TMAW 90-3S

Because of insufficient time, no formal action plan was derived in the "Program Stability" workshop (TMAW 90-3S).

Special Post AL-90 Issue Group Workshop

In a final effort to generate a "Program Stability" action plan, all AL-90 Issue Group representatives met on 16 May. Issue Group #1 provided some suggested implementation items to address "Program and related funding processes to improve stability".

In the end, action planning for all issues discussed in AL'90 was developed later by the AL'90 conference coordinator. That plan included actions to be taken by USD(A), the Service Acquisition Executives (SAE's), the Program Executive Officers (PEO), and the Program Managers (PM). Issue Group #1's product was reported to USD(A) together with the product of all other workgroups convened on that day to develop action plans for other issues.

SUMMARY OF DIFFERENCES BETWEEN THE TWO METHODOLOGIES

There were three basic kinds of differences in the way the two consensus methodologies were applied to the problem of "Program Stability":

1. The elapsed times from the start of the workshop process to its conclusion differed:

   - The NGT methodology process began on 18 December 1989 and ended on 25 May 1990.

   - The IM methodology process began on 1 March 1990 and ended on 1 April 1990.

2. The methodology used to generate questions was also different:

   - AL'90 questionnaires were examined and 55 which seemed to be related were aggregated together.

   - TMAW questions were derived by discussion among 3 people and focused directly on defining and working with the "Program Stability" issue.

3. The numbers of participants differed by a factor of three:

   - there were a total of 37 AL'90 participants who formed three separate groups. Each group had its own facilitator, and the way that facilitator applied the NGT methodology was different.

   - TMAW 90-3S consisted of 12 participants and one facilitator. The singular IM methodology was used.

PRODUCTS PRODUCED BY THE TWO METHODOLOGIES

NGT.

The AL'90 activity did not define what was meant by the term "Program Stability". Thus, although each of the three groups explored the same issue question:

> "What needs to be done to improve the program and related funding processes to improve stability?"

they had different ideas about what that question really meant.

Problems Defined

Each work group devised its own set of specific problems and potential ameliorating actions:

Group A defined 6 problems:

1. Lack of a mechanism to support/manage change as related to funding, application of resources, and external factors.
2. Lack of an overall plan describing where and how individual programs fit into larger schemes.
3. Unrealistic Service and/or DoD wide requirements imposed by players external to the program who are not accountable for program outcomes.
4. Timing disconnects related to funding cycles, milestones, required deliverables and other outputs, resource allocations.
5. Confused, unclear and changing priorities as reflected in funding support, other resource allocations, DoD/programmatic goals and objectives, political/strategic support.
6. The Program Planning and Budgeting System (PPBS) and associated requirements.

Group B developed 24 problem statements which they consolidated into 4 higher order problems:

1. Services unrealistic program appetites.
2. Lack of linkage between the Defense Acquisition Board (DAB) and PPBS processes.
3. Funding decisions in the hands of budget staffs instead of line staffs.
4. No one ever "shoots the wounded" *[i.e., cancels programs]*

Group C set forth its single issue in a narrative:

"....a major problem exists with program baseline....[it] is intended to be a management tool of significant value to the program execution chain, and yet as...currently implemented, there is little or no contribution to program stability. There is no connection between the baseline and the Biennial PPBS. Also there appears to be no link between the baseline and the process used for funding reductions when decrements are required....inadequate up-front planning..."

Potential Ameliorating Actions

Similarly, each group also developed its own set of barriers to solving the problems. Therefore, actions to be taken to reduce the problems were formulated in light of those barriers.

Group A stated a single action with 5 distinct parts:

Define and resource a process for managing changes that will:

1. Focus on clarifying priorities on an on-going basis, and on relating priorities to "national" and programmatic goals and objectives.
2. Clearly define roles and responsibilities of key players and required commitment and accountability as appropriate.
3. Place responsibility for managing funding changes with the DAE, SAE, and PEO.
4. Establish reasonable time lines to ensure proactive planning for allocating and applying programmatic resources.
5. Allocate funds for a sufficient "duration" to facilitate coherent coordinated planing and program implementation.

Group B defined 6 actions to overcome the problems it defined:

1. Establish definitive, quantifiable national strategy.
2. Prioritize programs and supporting infrastructure within realistic fiscal constraints.
3. Establish ownership and commitment to program the baseline by all parties.
4. Establish a process to link baseline and supporting infrastructure with the PPBS process.
6. Baseline impacts will be formally documented.

Group C developed 10 actions to overcome its singular problem:

1. Identify "core" programs - those of the highest priority that will not be changed.
2. Prioritize acquisition programs within the overall program environments....
3. Stick with an ironclad "cut from the bottom rule" where programs with minimal support will be killed, not nursed along....
4. Prioritize programs with mission areas and set priorities across mission areas....
5. Have "definitive" (i.e., with numbers and kinds of systems spelled out) military strategies....
6. Clearly define the nation's strategy....
7. Establish the pertinence of programs to the nation's strategy...
8. Eliminate unnecessary duplication of systems...
9. Quantify the acquisition program implications of national strategy...
10. Zero-base all programs to service missions and national defense strategy...

Consolidation of all of the ameliorating actions into a single "action set" was done after the groups had adopted the definition of what was meant by "Program Stability" derived in TMAW

90-3S (see below). The consolidated set of actions was divided into Short Term and Long Term actions to be taken by the Defense Acquisition Executive (DAE); Service Acquisition Executives (SAEs); Program Element Officers (PEOs); and Program Managrs (PMs).

There were 14 actions in all:

1. Request the Secretary of Defense (SECDEF) to direct the Office of the Secretary of Defense (OSD) and the Services to enforce corporate Acquisition Planning Budget commitment and ownership and concomitant linkage between APB and PPBS to accommodate changes. Any changes must be approved by the most recent PPB approval authority. PM's will be required to identify programmatic impacts.
2. Formulate an OSD legislative initiative to increase or create reprogramming authority and delegate appropriately to SAE/PEO.
3. Compile Service inputs and add anticipated OSD initiatives to identify required R&D funding for the pre-milestone I concept definition phase and submit as part of the OSD budget submission.
4. Request SECDEF to direct Service Chiefs within the Office of the Joint Chiefs of Staff (OJCS) to establish an annual process to link national strategy and weapon system requirements and to effect requirements prioritization through program and funding advocacy from the Joint and Specified Commands.
5. Request SECDEF to direct Service Acquisition Executives to establish program priorities based on weapon system requirement priorities identified by the OJCS.
6. Request SECDEF to direct OSD staff to develop Industrial Base Policy to support national strategy derived weapon system requirements and related program priorities to impact formulation of acquisition strategies.
7. Identify the requirement for R&D funding of the pre-Milestone I concept definition phase.
8. Enforce priority constrained allocation of program resource deductions.
9. Establish priority driven processes to execute delegated reprogramming authority among all service programs.
10. Establish priority driven process to execute delegated reprogramming authority among portfolio programs.
11. Focus more professional cost analysis manpower on early and continuous program office cost estimating.
12. Provide feedback to PEO/SAE/DAE when program commitments are not fulfilled.
13. Defer requirement advocacy to the user/operational command.
14. Establish sound risk management plan with supporting budget.

IM.

TMAW 90-3S defined the term "Program Stability" as follows:

A program is stable when it can be executed in accordance with an approved and adequately resourced plan; and approved program changes are the result of a timely, defined, and controlled process.

[The TMAW 90-3S definition was adopted by the AL'90 workgroups who met subsequent to the first AL'90 conference workshops. It provided a focus and was acknowledged as serving that purpose.]

TMAW participants defined 11 major

problem clusters (groups of problems which taken together had the meaning given in the cluster statement). Each problem generated a number of ameliorating actions which were called 'potential solutions'. For each of the 11 problem statements, participants selected one suggested ameliorating action as being the "most important" action which might be taken to help reduce that problem. The methodology permitted derivation of one suggested major action for each problem statement. The 11 problem statements and the suggested actions were:

1. OSD/Service failure to provide agreed upon resources:
Action: Link of DAB/ADM process with the service budgeting structure. Clearly state and educate the staff on the resource line of authority.

2. People outside the approval chain have the authority to delay the program without being held accountable for the delay and without any responsibilities for execution of the program.
Action: Hold them accountable. Once milestone approval is signed, staffers can only effect changes with approval of the same person who approved the program.

3. Lack of direct control over resources.
Action: PM write performance report on lead matrix individuals.

4. Unclear and changing requirements.
Action: Once program is approved and committed any change that impacts cost or schedule must be justified to the approving authority by the staff proposing the change, and if approved, then the program manager is to restructure program and commitments.

5. Lack of or undisciplined strategic planning.
Action: Be realistic on what can be done. Include real world experience and budget accordingly.

6. Funding changes or problems.
Action: Take dollars in an integrated way. Do not fence "takes" to the mission area. Do this at an appropriately aggregated level within the acquisition community where proper priorities can be applied and program impacts understood. (Small programs may out-rank the last item of a long production run).

7. Changes to acquisition strategy and plan without adequate resource adjustments.
Action: Enforce "binding contract" across the service to include budgeting staff, "operators", etc. PM/PEO have to concur with change impact assessment (ownership). Provide the feedback mechanisms where the PM notifies the chain of the lack of promised resources and automatic fail safe program cut procedure.

8. Poor program execution.
Action: Require and support a management reserve (dollars/schedules) with a risk management plan.

9. Congressional mistrust and meddling and language.
Action: Stress need to tie force structure, and weapons procurement and planning stability to the DoD grand strategy/war fighting capability. DoD and Services should make a better effort to tie answers to Congressional questions back to the strategy.

10. Lack of timely decisions.
Action: Put mechanism in place to force decisions to meet need established by the PM. Reduce the staffs.

11. Overly restrictive regulations not tailorable in practice.
Action: Program managers should be able to obtain waivers of any requirement that is not law imposed by an advocate or staff function from the PEO. A signed justification for file should be required and concurrent notice provided to the staff function. Only the SAE/DAE, as appropriate, should have the authority to reverse the waiver once granted. (Complete the acquisition data base so that we can easily identify what is law.)

COMPARISON OF THE PRODUCTS GENERATED BY THE TWO METHODOLOGIES

Initial Thoughts

There are a number of things which might affect the products produced using the two methodologies. I have put these ideas in the form of questions.

1. Did using different methodologies to generate the questions posed make a difference?

The question used in AL'90 was different from the question in TMAW 90-3S: The AL'90 focus was on "what needs to be done to improve the program and related funding processes to improve program stability" rather than on program stability *per se*.

In the end, the TMAW definition of program stability focused the discussion. Since it embraced the need to improve the system to make it more capable of more rapid response to change, the argument can be made that the different questions had little effect on the outcomes.

But there is bound to have been some effect on the perception the participants had of what "program stability" meant that was due to the difference in group focus *right from the beginning*.

The difference likely lies in the emphasis the TMAW definition placed on response to change. TMAW participants focused on achieving a system with good dynamic response. AL'90 participants came to that realization only after the initial three workshops were completed; and then only by introducing the TMAW definition of program stability.

Indeed the wording of the AL'90 question weighted discussion to devising acquisition system changes which would help provide more stable *funding and other resource levels - and* that would help program stability.

TMAW participants sought ways to devise acquisition system remedies that would accommodate change as, and when needed.

In short; there is good reason to believe that the way the questions were generated made a difference in the tenor of the entire discussion.

2. Did the AL'90 process of "aggregating a product" (consolidating the output of a number of independent groups) provide a different level of detail in both problem and action set than was obtained by the TMAW process of "formulating an integrated product" (creating an integrated whole within the same continuing group of participants)?

The answer to that question really devolves on asking two other ones:

"Will the final set of suggested actions as presented to USD(A) in the AL'90 report, if implemented, significantly affect the problems expressed by the TMAW participants?"; and,

"Can the actions suggested by TMAW be easily incorporated within the action set proposed by AL'90?"

It could be argued that adopting the TMAW 90-3S "program stability definition" within the body of the AL'90 final product insures that all of the concerns of both groups have been considered fully. But is that really likely? How much congruity is there between the two sets of problems and actions?

In particular: If SECDEF did

"Direct Service Chiefs within OJCS to establish an annual process to link national strategy and weapon system requirements and to effect requirements prioritization through program and funding advocacy from the Joint and Specified Commands" (Lines 16 through 20 on Page 4 of the final report of the AL'90 conference),

Would that action ameliorate, or have a positive effect on any of the problems raised in TMAW 90-3S which dealt with "Requirements" and "Joint Service" issues? Specially, would the action help overcome

14. Failure to account for interdependency with other programs (Page 7 of TMAW 90-3S Report),

36. Inability to obtain joint service decisions (Page 9 of TMAW 90-3S Report), and

67. Threat and intelligence estimates change (Page 11 of TMAW 90-3S Report)?

Perhaps more to the point: Is there internal self-consistency in the AL'90 final report and the work of the individual groups - or has something been changed in applying the amalgamation process? Would SECDEF's action also serve to ameliorate those AL-90 problems developed by

Group 1: Poor up-front planning (inadequate user requirements, funding & program definition).

Group 6: Problem #5: Confused, unclear, changing priorities as reflected in... funding support...other resource allocations...DoD/programmatic goals and objectives...political/strategic support

Group 13: Problem #23: DAE/SAE not involved enough in requirements process.

In some ways, the process used to consolidate AL-90 results with TMAW 90-3S results is similar to that used to derive a single set of problems and responses from 4 separate USD(A) Smart Munitions Acquisition Improvement Program workshops. In the smart munitions effort, workshop integrity and continuity was provided for by selecting a member from each of the four workshops to champion that workshop's point of view to a task force. The task force members were drawn from outside of the workshop groups. In the AL-90 TMAW 90-3S consolidation, consideration of the TMAW 90-3S stability issues was demonstrated when Group 6 included excerpts from the TMAW 90-3S executive summary in its interim report. In preparing their final AL-90 report, the representatives of AL-90 groups 1, 6, and 13 asked for and received a copy of the TMAW 90-3S report to which they subsequently referred in their final report of deliberations.

Thus, while it is unclear whether the

two methodologies produced totally congruent results, an effort to do so was made. I would argue that the effort only partially met its objective. I believe there remain considerable differences between AL'90 and TMAW 90-3S perceived problems and their recommended solutions.

Other Observations

The recommended actions from the final report of AL-90 with regard to Issue #1 are broadly stated. The recommended actions in TMAW 90-3S are much more specific. For Example:

The AL'90 legislative activity focuses on reprogramming authority issues. The TMAW 90-3S legislative concern is with many other aspects of the problem from the daily working of the OSD and Service staffs to publishing the results of Congressional direction.

The AL'90 Requirements activity focuses on tying strategy and force structure to requirements. The TMAW 90-3S concerns are with creating a process within DoD which can accommodate rapid changes to requirements within the PM's authority.

The AL'90 recommendations for generic acquisition system change are concerned with the overall process. TMAW 90-3S concerns are again with operating levels of daily activity.

The basic differences between TMAW 90-3S and the AL'90 recommendations have to do with the level at which problems to be solved are stated: TMAW's level of concern is with carrying out the program after it has been initiated. Those concerns, while real do not have much "big picture" focus. AL'90 does rise to the level of the SAE's and DAE's.

It might be said that unless the AL'90 recommendations and action planning are carefully crafted, they may not address the issues raised in TMAW 90-3S which pertain directly to managing the acquisition programs in being. If that did happen, we might well be unable to accommodate the kinds of actions TMAW 90-3S participants believed were necessary to achieve an acquisition process more responsive to change.

CONCLUSIONS

Our analysis indicates there is considerable congruity between ideas generated at the AL'90 and the TMAW-90-3S workshops. The congruity is interpreted as an indicator of an underlying consensus within the acquisition community as a whole regarding initiatives required for improving the overall issue of "program stability".

However I believe there are some real differences in the level of detail addressed when applying the two methods as was done in this case.

The "aggregate up" (AL'90) methodology broadens the problem statements and the actions proposed to overcome them. This probably results from the requirement to incorporate a larger number of ideas within a single structure in order to achieve consensus. The danger in "aggregating up" is the loss of specificity which results. When dealing with a complex system, when we lose detail, there can be considerable difficulty in devising actions necessary to insure that the modifications desired really are made. I call this the "Ten Commandments Syndrome": Everyone can agree with the high level objectives, but implementing a plan to achieve them is likely to be very difficult.

Another difficulty with iterating a process over a long period of time is

that while participants are busy achieving understanding, the problem and the environment in which it exists may change significantly. Change might even be so great as to invalidate some of the conclusions reached and the action options generated at the start of the work.

Most of the changes the acquisition community experiences are outside the influence of that community. In effect: taking the time necessary to craft sufficiently detailed plans may obviate their applicability.

Finally, it may be that the levels of detail we demand in our problem and action analysis activity takes so long that significant change to the environment within which we operate is inevitable. If that were the case, we would need to search for a different paradigm - one which permits parallel rather than sequential planning and action.

What seems clear is that because we are attacking problems which are extremely complex, and because those problems are embedded within highly interdependent systems, we will need to be very careful in how we devise and implement solutions to our perceived problems.

Our experience has provided us with considerable understanding about methodology limitations in the context of seeking to solve complex problems. We continue to look at ways to expand our knowledge with the certainty that we *can* make a difference and help develop a better acquisition process.

COMPETITION OR OPTIMIZATION?

Dr. Thomas M. Clarke, U.S. ALMC

ABSTRACT

The concept of efficient acquisition decision making is discussed in the context of competing and inconsistent decision criteria. Simple game theory is then used to reconsider optimal DOD/contractor behavior in light of a shrinking defense market. The paper suggests that defense might be optimized by less insistence on formal competition, and more attention to the institutional rules governing long-term incentives for or against cooperative acquisition behavior. Experimental data and European experience are used to illustrate the argument.

INTRODUCTION

Thirty years ago defense decisionmakers faced a simple optimization problem: maximize the performance of desired weapon systems. Occasionally developers also sought to minimize time between development and fielding, but not at the expense of performance. Today the decision problem is much more complicated. Congress and the Department of Defense (DOD) now ask program managers (PM's) to simultaneously maximize performance and minimize schedule and cost. Since these goals are contradictory, no clearly optimal solution is available. This much is common knowledge.

Unfortunately, it is also widely believed that the DOD currently fails to optimize any of these goals. Hence, a military correspondent for a major newspaper recently wrote that defense procurement was "inefficient and corrupt." Shockingly, he said that poor performance was now seen as routine and expected.

Just as the problems facing defense are well known, so are the solutions--or so it seems. Many defense analysts attribute the reigning confusion to the absence of a national strategy guiding weapons procurement.[1] Others point to program instability[2], lack of attention to quality[3], an adversarial government/contractor relationship[4], too friendly a relationship[5], or technical problems.[6] For the last decade, the preferred solution has been competition. In the land of free enterprise, the sole source contract is an easy target.

COMPETITION

Politicians thought competition provided a simple answer to the defense mess, and laws were passed to rectify the situation. Economists were quick to point out that what looked like competition to Congress looked more like a defense contractor tea party to them. It is not hard to see why.

Defense markets are not competitive markets. On both the supply and demand side, participants are few in number and can affect prices by their actions. The demand side is a monopsony, one buyer, and the supply side is at best a limited oligopoly, a few large firms. Profit margins are usually set explicitly in contracts and limited by regulation. Most firms are not free to leave the market, except by bankruptcy. With the exception of Boeing, which isolates its defense division, the major defense contractors do almost no commercial business. Attempts to brave the rigors of the market end dismally in most cases.

Small oligopolies in defense do what they do everywhere: behave strategically. To game theorists, strategic behavior refers to systematic attempts to achieve a best possible outcome in uncertain situations where the decisions of other actors affect what will happen. When two to four defense contractors are bidding on a dual source contract, economists expect a strategy of tacit collusion much of the time. A growing body of evidence suggests that implicit cooperation is exactly what happens.[7]

Nevertheless, a folk belief persists that two contractors must be better than one, and consultants are duly hired to prove it. Although a popular rule of thumb says that competition will decrease unit production costs by 25%,

empirical studies find apparent savings more in the range of 10% to 15%.[8] About one-third of all systems studied cost more under competition. The analytic methods underlying these weaker claims are now widely debated, causing one consultant to reject the use of current models of competition benefits.[9]

Anyone familiar with "learning curves" can quickly calculate that dividing a reasonable production run in half will drive up the total cost by 5% to 25%, depending on the assumed slope. When the costs of transferring technology and tooling up are included for the second source, it is easier to see why the gains from "competition" are disappointing.

The negative influence of dual sourcing or alternating winner-take-all contracts on quality is now beginning to worry defense officials.[10] The DOD is also backing away from a policy of the late 1980's to explicitly shift development risk away from the government and reduce contractor profits. This policy was pursued so effectively that it is now thought to be threatening the industrial base.[11]

Leaving these issues to one side, we might ask why dual sourcing so often fails to deliver a better product? The predictions of the literature on oligopolistic strategy appear to be borne out by the phenomenon of the "happy loser." The firm, as a profit or revenue maximizer, can often do better to lose a dual source competition. With a customary 60/40 production split, the loser may achieve a higher profit by producing 40% of the total production at a higher unit cost. In fact, simulation studies show that the production split would have to shift to at least 85/15 to provide a significant incentive for both contractors to compete using price.[12]

Contractor price strategy is another reason competition may not be effective. The absence of a truly competitive market means prices are not set by the market. Consequently, firms are free to pursue price strategies, typically either penetration or skimming.[13] Because penetration is a riskier approach to a naturally uncertain market, defense contractors will normally skim unless there is significant industry over-capacity or a high proportion of the program is funded upfront.[14]

Riordan and Sappington constructed a detailed micro-economic model of the incentive structures accompanying sole source and dual source procurements, respectively. Model results suggest that sole source procurements are preferable to competition under many conditions common to defense procurement.[15] Among others, these conditions include rapid obsolescence, a low discount rate on future benefits, lengthy development, and high probability of a cost overrun. Traditional approaches to competition analysis may also ignore a number of costs to dual sourcing that are difficult to quantify but potentially significant.

OPTIMIZING GAMES

Given a fundamentally noncompetitive defense market, the debate between sole source procurements and various types of competition may be a red herring, blinding us to more effective solutions. Simply put, changing the institutional rules underlying both government and contractor incentives is more likely to foster optimal defense acquisitions.

To see why, we will investigate the structure of some simple games. Game theory provides a useful analytic tool for situations where the outcomes of decisions are interdependent, conditions are uncertain, and expectations are important.

Static Prisoner's Dilemma. Game theorists first devised the well known Prisoner's Dilemma (PD)

Figure 1. Prisoner's Dilemma

		Contractor: Cooperate	Contractor: Compete
Government	Cooperate	3 Trust 3	5 Temptation 0
Government	Compete	0 Temptation 5	1 Fear 1

game in the 1950's. It describes a two-player game where each player has a choice between cooperating and competing. The payoffs for each of the four possible pairs of stategies are defined to produce a game structured so that the optimal individual strategy leads to a suboptimal "social" outcome. Figure 1 contains an illustrative payoff structure.

If one player competes and the other does not, then the competing player receives the highest possible payoff, and the cooperating player receives the lowest possible payoff. The risk is that mutual competition has the second worst payoff for both players.

Played once with no communication between players, the optimal expected value strategy is competition. Ironically, the average payoff to <u>both</u> players is higher under mutual cooperation. If you are a taxpayer interested in the best long-term defense, rather than a defense contractor or government PM, then the mutually cooperative strategy is socially optimal. The problem is how to change the rules to encourage cooperation.

If communication between players is possible, each player may signal a desire to cooperate. Unless these claims are backed by trust, there may still be no change in strategy by either player. In fact, the central problem of this game is to establish trust.

Dynamic Prisoner's Dilemma. If the game is played only once, there is no way to overcome suspicion. In contrast, playing the game repeatedly over time allows each player to establish a track record and get some idea of the strategy followed by the other player. Moore and Moore show that adaptive learning will take place during repeated PD games if accurate messages concerning each player's intent are sent and received.[16]

Accurate interpretation of these messages is a significant problem in experiments and the real world. Experimental data show that people typically commit "attribution errors" when playing repeated PD games.[17] Attribution error occurs when a player believes an action is due to personal intent, when it is really caused by the structure of the game.

In PD games, cooperative players tend to accurately perceive the strategies of other players, whether cooperative or competitive. Competitive players, because their own intent is to compete, often commit attribution errors, interpreting the strategies of all players as competitive. Eventually, the prophecy becomes self-fulfilling because of the game structure.[18] Once again, the central problem is to build trust.

BUILDING COOPERATION

Axelrod carefully studied optimal strategies in repeated PD games, and found that a "tit-for-tat" (TFT) strategy was usually most successful.[19] A tit-for-tat strategy reciprocates both cooperative and competitive moves. To be truly effective, TFT must be "nice" (never play a competitive move first) and "forgiving" (punish a competitive move only once). The only significant constraint on the effectiveness of TFT is the discount rate on future actions. If future moves are heavily discounted, the game collapses toward a static PD game where competition pays.

Cooperative strategies during repeated PD games are also threatened by envy and cleverness.[20] Envy occurs when players incorrectly reinterpret the game as zero-sum. Even though each player is better off than either would be with competition, one player inevitably is ahead at any point in time. In order to catch up, the lagging player is tempted to compete. Disaster may follow.

TFT is a simple strategy, tempting players to try a more sophisticated approach. Simulations show that more complicated strategies in fact do worse with repeated PD games.[21] Compounding the woe, other players may not be able to understand what the strategy really is, and commit attribution errors leading back toward competition.

COOPERATION

The Acquisition Game. Is defense acquisition a PD game? The analogy may be close enough to provide insight. If the strategy definition for the PD game is interpreted as shown in Figure 2, those familiar with acquisition may recognize the mutual competition strategy from their own

Figure 2. Strategy Definitions

	CONTRACTOR
Cooperate	Efficient Effort Honest Cost Accounting Informal Negotiations
Compete	Juggle Books Gold Plate Letter of Contract
	GOVERNMENT
Cooperate	Stable Program Minimal Audits Functional Specifications Informal Negotiations
Compete	Program Instability Burdensome Oversight Detailed Specifications Letter of Contract

experiences.

Veterans of the procurement wars find that both the DOD and contractors pursue competitive strategies resulting in a very adversarial climate in defense markets.[22] When defense contractors temporarily gain the upper hand and reap large profits, as during the Reagan buildup, the government retaliates by shifting risk to contractors and forcing competition. Voters and the Congress see these actions as appropriate, voicing a classic American belief that mutual competition will optimize markets--including the defense market. Confidence in that dictum is hard to shake, even when faced by an endless series of defense fiascos.

Moving Toward Cooperation. How do we get from mutual competition to the more optimal mutual cooperation? Because we have gone so far down the adversarial path, cooperation first requires the re-establishment of trust.[23] Several structural conditions reinforcing cooperative intent are already in place; including frequent and long-term interactions among a relatively small group of players. Prevailing norms for consensus already exist, and incremental program funding breaks the PD game down into a series of linked plays. As Axelrod puts it, these circumstances "enlarge the shadow of the future," and lower the implicit discount rate on future plays of the game.

Too Much Cooperation. Some analysts believe that too much cooperation already exists. Hampson argues that direct and implicit collusion between contractors and various government officials (including Congress) is frequent.[24] Few programs are killed, regardless of cost or performance. Even the Secretary of Defense may inadvertently act like an oligopolistic "price leader" by setting and announcing budgetary targets.

Two problems underly this anomaly. A TFT strategy must be clearly communicated to be successful. The government wavers inconsistently between competition (not always justified) and cooperation (not always deserved). No general strategy is apparent, and the arbitrary nature of individual plays leaves contractors wary.

Likewise, the TFT strategy requires prompt and clear punishment, followed by forgiveness. If no systematic link between contractor performance and future contracts exists, then TFT is not in effect. Although contractor fines and temporary suspensions do occasionally occur, they rarely affect the flow of revenue to major defense contractors in a significant way. In fact, maintenance of the industrial base is often used as an excuse to avoid punishment.

Shrinking Markets. The steady increase in unit costs for weapons and declining acquisition budgets will probably force many contractors out of the defense market permanently. Competition will be impossible or uneconomic for many projects. Faced with this kind of future, the government may be better served by explicitly striving for optimal returns under mutual cooperation.

Pentagon officials are now starting to echo management consultants in the private sector who call for the establishment of long-term relationships with suppliers, based on clear quality standards.[25] Obstacles in the way of government application of this philosophy include numerous regulations making such behavior illegal and the absence of a credible will to punish suppliers who do not perform.

Our European allies have fostered close relationships with individual suppliers for both good and bad reasons by artificially limiting possible suppliers to their own national defense markets.[26] The benefits of mutual cooperation were then masked by high costs, due to an uneconomic market size. The Europeans recently decided to use the Independent European Industries Program Group (IEPG) as a forum to rationalize the European defense market, while maintaining the advantages of cooperative efforts.

ZERO-SUM BUDGETS

Government vs. Government. Because controversy surrounding competition has dominated recent acquisition research, most attention focuses on the interaction between government and contractor. Viewing the government as a unitary actor is a useful analytic fiction at times, but it can also obscure internal acquisition games.

During periods when both the federal and defense budgets are expanding, a PD game is again possible. Critics of cooperation accurately perceive a willingness to form mutual protection societies in defense of questionable projects. The onset of severe budget wars raises the short-term payoffs to competitive strategies. Faced with a credible threat of program cancellation because of shrinking budgets, government players may soon decide that they are now part of a zero-sum game. Of course, the only rational strategy in a zero-sum game is competition.

Contractor vs. Contractor. Criticisms of dual source acquisition strategies often hinge on the less than competitive behavior of oligopolies. In the boom Reagan defense market, some defense contractors became specialists at bidding to be followers on leader/follower production contracts. The current shakeout in defense markets has already forced some contractors to use a competitive strategy in what has become a zero-sum game. The premier example is domestic shipyards bidding at below cost on competed production contracts to stay in business.

THE DEFENSE GAME

Free Riders. The n-player version of PD occurs with the provision of collective or public goods.[27] Defense is a classic example of such a good that is provided to all or none, regardless of who pays for it. So-called "free riders" may enjoy the benefits of defense spending, while avoiding the taxes which support it. The problem occurs in defense markets under either mutual competition or mutual cooperation.

If the government adopts a competition strategy, all contractors are penalized by low profits, excessive oversight, risk, and program instability. Contractors playing competitive strategies, in the sense of Figure 2, may deserve this treatment. Cooperating contractors do not, and find themselves in the cell with the worst possible payoff. Those unjustly penalized will soon realize that they too must use a competitive strategy to survive.

The mirror image of this problem occurs when the government is unfailingly cooperative. Competitive contractors reap windfalls, and the government gets substandard equipment at a cost over budget. In order for a TFT strategy to succeed, the government must free itself to appropriately reward or punish contractors for their behavior.

If burdensome regulations, reports, and audits are seen by contractors as punishment, then we see that solutions to the free rider problem require fundamental changes in the way the government handles its legal relations with contractors. Ideally, the government should allow itself to use the same set of informal rewards and sanctions applied by commercial businesses.[28].

Distributional Coalitions. The same economic theory underlying the provision of public goods can be extended to explain the presence or absence of certain kinds of groups or coalitions. Olson uses this theory to explain why interest group politics in this country has come to dominate political forces attempting to serve the general public good.[29] Thus, defense contractors and the military services are represented by powerful lobbies, while "disinterested" voices for a coherent weapons acquisition strategy or a reduction in the government deficit go unheard.

The dominance of Olson's "distributional coalitions" is a special case of a general paradox widely studied by game theorists and economists. Situations are common in life where individuals may each behave in ways calculated to benefit themselves, but the summed effect leaves them worse off as a group than before.[30]

Since the time of Adam Smith, our economic system was guaranteed to have just the opposite effect, and the powerful prosperity that resulted has led us to favor mutual competition strategies ever since. The essence of the n-player PD game is that single players do not perceive the contradiction between individual rationality and social irrationality. The Defense Game seems to be a case in point.

SUMMARY

If mutual competition has failed as an acquisition strategy, then the adoption of a TFT strategy by the government merits consideration. Successful implementation of TFT acquisition implies a radical change in the way the government does business with defense contractors. At the very least, the following steps are necessary:

1) A public commitment to the TFT strategy by the government.

2) A credible structure of rewards and punishments applied in a timely and non-arbitrary way.

3) A clear statement of expected behavior to potential defense contractors.

4) Revisions of present law allowing the government to play a cooperative move when desired.

None of these steps is easy to implement. The legacy of mutual competition is suspicion and mistrust. Voters, politicians, businessmen, and bureaucrats must be convinced that the optimal path for defense acquisition in the years ahead may well be cooperation.

ENDNOTES

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19. Robert Axelrod, The Evolution of Cooperation (Basic Books, 1984).

20. Ibid.

21. Ibid.

22. See Lee, op. cit.; also Bill Drinnon and David Hodulich, "Production Competition Lessons Learned: Incumbent Contractor Torpedoes," Program Manager, May-June 1989, pp. 83-85.

23. See Shlomo Maital and Sharone Maital, Economic Games People Play (Basic Books, 1984).

24. Hampson, op. cit.

25. See note 10; also Richard Stubbing and Richard Mendel, "How to Save $50 Billion a Year," Atlantic Monthly, June 1989, pp. 53-58.

26. See Willie E. Cole, "Reshaping the Demand Side of the European Armaments Market," Program Manager, Nov-Dec 1990, pp. 4-10.

27. See Mancur Olson, The Logic of Collective Action (Harvard Univ., 1965), for a basic exposition of the theory.

28. See Lee, op. cit.

29. Mancur Olson, The Rise and Decline of Nations (Yale Univ., 1982).

30. See Thomas Schelling, Micromotives and Macrobehavior (Norton, 1978), for a clear explanation of how this process works.

A PROPOSED TAXONOMY FOR FEDERAL GOVERNMENT GOODS

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ABSTRACT

This paper is the report of a research effort to develop a method for classifying various goods procured by the Federal Government according to key characteristics or attributes exhibited by these goods. The primary objective was to develop a classification scheme that practitioners and researchers could use in grouping goods along a continuum from simple to complex utilizing characteristics other than purely physical attributes.

Using 21 randomly selected goods and a scaling process, a survey was conducted to determine the relationship between these goods and the chosen characteristics. Cluster analysis was then conducted to group the goods into categories that exhibited similar characteristics. A taxonomical structure for classifyi‑‑ the population of Government goods in five categories using six distinctive attributes was developed. From such a classification, relationships among goods and classes of goods can be examined and evaluated.

The potential uses of such a scheme include refinement of acquisition policy to reflect differences between classes of goods, training and education of the acquisition workforce, and implications for the staffing and directing of procurement functions within Federal Government buying organizations. The taxonomical model developed through this research can be employed by researchers in the process of establishing and studying critical relationships between goods and by practitioners in developing and implementing procurement policies and procedures.

INTRODUCTION

Contracting as a Science

Many researchers in the field of Government procurement have proposed that contracting is a science. In order to be recognized as a science, various criteria, in the form of underlying principles must first be met. One of these underlying principles is a description and classification of the discipline's subject matter. [1]

Several studies have examined classification schemes within the Federal procurement environment. Some of these have focused on the procurement process. [2] [3] Others have attempted to classify the tasks performed by the contracting officer. [4] [5] Yet another has proposed a classification of contracting literature. [6]

The paramount purpose for classification is to describe the structure (nature) and relationship of the

constituent objects to each other and to similar objects. From this, relationships are simplified in such a way that general statements can be made about the classes of objects. [7] Such general statements are extremely useful for establishing policies and procedures.

The Need for a Strategic Scheme

While the result of these taxonomical studies have been significant, they do not exhaust the methods of beneficially classifying the contracting subject matter. One further taxonomical approach is based on the type of good procured by the Federal Government. As one of the major elements of the subject matter, types of goods represent an area where classification efforts have been few and limited.

Within the Government, there are essentially only two classification schemes used for categorizing the goods the Government buys. The first of these is the Federal Supply Classification (FSC). FSC is a commodity classification which categorizes the myriad of goods by their commodity group. Groups, and classes within these groups, have been established for the universe of goods with emphasis on items known to be in the supply systems of the Federal Government. [8]

The second method of classification is the Standard Industrial Classification (SIC) of commercial organizations. The SIC scheme is organized to reflect the structure of the U.S. economy with the business establishment as the unit classified. [9]

While both the FSC and SIC approaches to classification serve their purpose, both do little to provide insight into strategic approaches to buying Government goods. It appears potentially useful to segment goods into clusters in which individual goods share the same end-item characteristics. These characteristics would not be associated with just the physical nature of the goods but would focus more on the considerations deemed important in the buying process.

A major problem today in procurement is that Government purchased goods are quite often perceived by legislators and critics of the procurement process as a single homogenous grouping. [10] Frequently when additional oversight is mandated, little thought is given to the differences in product complexity or procurement procedures involved.

General Benefits of a Strategic Classification

If in classifying, the perspective taken was to view goods from simple to complex, such goods could then be described in such a manner that a categorization along a continuum between the two extremes is possible. With the wide variety of items, from the very simple to the highly complex or common to unique, procured by the Government, there should be a way to categorically classify these goods in a useful structure. Such a structure or classification scheme would allow for a systematic categorization of goods across a spectrum from the relatively simple, off-the-shelf type items, to sophisticated and complex systems.

The major benefit of such a strategic scheme would be that more accurate and perceptive questions could be asked concerning the relationships between various classes of goods and how best to utilize these relationships. A

classification model would provide the structure necessary for identifying all the various types of Government purchased goods in a profile that lends itself to increased visibility. The subsequent treatment of these goods by logical groupings would be facilitated by a taxonomical structure that highlights the differences.

An accurate determination of the best procurement strategies for buying certain products is yet another key benefit of having a goods classification scheme. For example, contracting officers could determine which specific group of buyers and which acquisition methods would be most effective. Likewise, researchers would have a structure for adequately addressing the differences in contracting goods based on critical characteristics.

A PROPOSED TAXONOMICAL STRUCTURE

As identified by Fleishman and Quaintance [11], one of the first steps in developing a taxonomy is identifying the conceptual basis for the classification. As mentioned earlier, the basis for this proposed taxonomy is strategic insight. In other words, if Government goods were categorized across the spectrum from simple to complex, those characteristics or attributes that best describe the goods from a buyer's perspective would be candidates for inclusion.

Determining the Characteristics

With a basis for the classification effort, the next step in the process is determining the characteristics or attributes of the objects under consideration. To arrive at the characteristics, a preliminary set of attributes based primarily on literature review was developed. Using Gordon Miracle's [12] selected product characteristics and Robert Judson's analysis of the acquisition environment, 22 preparatory characteristics were identified. Next, interviews were conducted with members of an expert panel to narrow and refine the preliminary list into a workable number and understandable format. Based on these expert panel interviews, 12 attributes or characteristics were finally settled upon to describe Government goods from a strategic buyer sense. Table I contains these characteristics.

TABLE I

Characteristics of the Goods

Change
Complexity
Customization
Maintainability
Homogeneity
Consumption
Unit Cost
Documentation
Item Attention
Sources
Criticality
Stability

These characteristics were defined and then scaled from one to five to allow comparisons to be made between a particular good and the attributes. The 12 resultant characteristics, their definitions, and scales appear below.

1. **Change** describes the good's rate of technological transformation. With some goods, their rate of technological change is very low. Their design is fixed and rarely, if ever, changes. Contrast this with those goods that are affected by state-of-the art technology and are characterized by a high rate of technological obsolescence.

SCALE:
1 Very low rate of technological change
2 Low rate of technological change
3 Medium amount of technological change
4 High rate of technological change
5 Very high rate of technological change

2. **Complexity** describes the good's technical intricacies. The degree of a good's technical complexity may be thought of in terms of the skill and expertise needed to produce the good. Another way to determine complexity is whether the good is a system, sub-assembly, component, piece part, or raw material. For scoring purposes, 1 indicates little or no technological complexity with 5 being very high complexity.

SCALE:
1 Very low technical complexity
2 Low technical complexity
3 Medium technical complexity
4 High technical complexity
5 Very high technical complexity

3. **Customization** is the degree to which the good is manufactured to the buyer's specifications. Some goods, those that are strictly commercial, have no amount of customization while others are produced exclusively for a buyer, e.g. the Government. Goods that are not customized should be scored 1 with those developed exclusively for the Government scored 5.

SCALE:
1 No amount of customization
2 Low degree of customization
3 Medium amount of customization
4 High amount of customization
5 Made exclusively for the Government

4. **Maintainability** refers to the amount of maintenance considerations associated with the good. In other words, how frequently, if at all, is maintenance is required on the good. Some goods are virtually maintenance-free while others require a great deal of maintenance throughout their lives.

SCALE:
1 No maintenance required
2 Low maintenance requirements
3 Medium maintenance requirements
4 High maintenance requirements
5 Very high maintenance requirements

5. **Homogeneity** represents the number of other goods that are similar and are ready substitutes for the good under consideration. Typically, the more common the use of the good, the greater the amount of homogeneity. Highly homogeneous goods should be scored 1 and those with little or none scored 5.

SCALE:
1 Very high homogeneity
2 High homogeneity
3 Medium homogeneity
4 Low homogeneity
5 No homogeneity

6. **Consumption** refers to how rapidly the good is used by the buyer. Some goods are consumed on a continuing basis and require constant replenishment.

Others are of a more permanent nature resulting in much less frequent buying. Rapidly consumed goods should be scored 1 and 5 used for goods that are rarely consumed or replaced.

SCALE:

1 Very rapidly consumed, constant replenishment

2 Rapidly consumed good, constant replenishment

3 Moderate consumption and replenishment

4 Low rate of consumption and replenishment

5 Very low rate of consumption and replenishment

7. **Unit cost** is the good's cost to the buyer. Generally speaking, as a good becomes more unique to the buyer's requirement, the unit value is increasing. To score, use 1 for low unit cost and 5 for very high.

SCALE:

1 Very low unit cost

2 Low unit cost

3 Medium unit cost

4 High unit cost

5 Very high unit cost

8. **Documentation** is another characteristic external to the good yet many times a necessary part of it. Frequently the Government requires substantiating documentation in the form of drawings, technical manuals, and certifications for some types of goods while for others little at all is required. When scoring, a 1 would indicate a good purchased with no accompanying documentation while 5 is for goods accompanied by drawings, technical manuals, etc.

SCALE:

1 No associated documentation

2 Low amount of documentation

3 Medium amount of documentation

4 Great deal of documentation

5 Very high amount of documentation

9. **Item attention** given by the buyer refers to single-item versus volume or mass buying. When a buyer deals with small dollar-value items like common bolts and rivets, the focus is on a mass quantity of these types of goods. Contrast this with the acquisition of a F-14 aircraft where the buyer's attention is focused on a single item.

SCALE:

1 Complete volume-type attention

2 Mostly volume-type attention

3 Good that could be either volume or single item

4 Good that is usually single-item attention

5 Good that is always single-item attention

10. **Sources** refers to the number of available sources that provide the same basic type of good. Some types of goods have associated with them a great number of alternate sources while others of a more specialized nature are more restrictive.

SCALE:

1 Virtually unlimited number of suppliers

2 High number of suppliers

3 Adequate number of suppliers

4 One or two sources

5 No sources exist

11. **Criticality** refers to the buying urgency associated with the good or the necessity of having the good available for the buyer to purchase. This characteristic of a good can be quite dynamic, but some goods, by their nature, may rarely be characterized as critical to the buyer.

SCALE:
1 Never characterized as a critical item
2 Rarely a critical item
3 Sometimes approached as critical
4 Usually considered critical
5 Always purchased under critical situations

12. Stability refers to the nature of the requirement. With some goods their demand is constant and seldom varies. On the other hand, demand for certain types of goods is much more volatile and uncertain depending on the need for the good and perhaps the technology that is available.

SCALE:
1 Good that is extremely stable
2 High degree of stability
3 Moderate amount of stability
4 Low amount of stability
5 Highly unstable good

Determining the Categories

As the next stage in constructing the scheme, a survey was conducted involving 139 National Contract Management Association (NCMA) fellows. The purpose of the survey was to have the participants assess the relationship between the 12 proposed attributes and 21 sample goods with the scales representing the varying degrees of presence or absence of each attribute.

The sample group of 21 goods was selected to represent a wide variety of items the Government buys. Goods within the sample ranged from the very simple, such as sandpaper, to the very complex, such as a fire-control embedded computer. The scoring sheet used by respondents is presented as Figure 1.

The responses to the questionnaire were combined into a single mean value matrix. The resultant average values represented a description of the goods in terms of the 12 attributes. Using cluster analysis, the mean value matrix of 21 individual goods was divided into five discrete clusters of relatively similar objects. Cluster analysis is currently the most popular numerical taxonomy method used to construct classification schemes. [13]

Refining the Number of Characteristics

Along with an examination of the range of mean values for each of the 12 attributes, cluster analysis signalled the possible elimination of six attributes. While those attributes eliminated could describe the goods, their relative consistency across the various groups added little to the distinction between the goods. Because their consideration did not essentially add to the differentiation between the clusters, retaining them merely caused a burden to the classification scoring process.
Table II contains the six selected characteristics which were retained in the model.

GOODS & CHARACTERISTICS

Goods \ Characteristics	1. CHANGE	2. COMPLEXITY	3. CUSTOMIZATION	4. MAINTAINABILITY	5. HOMOGENEITY	6. CONSUMPTION	7. UNIT COST	8. DOCUMENTATION	9. ITEM ATTENTION	10. SOURCES	11. CRITICALITY	12. STABILITY	13. IMPORTANT CHARACTERISTICS & PRIORITY	14. COMMENTS
1. Steam Turbine	3	3	3	3	2	4	3	4	4	3	2	3	9 - 6 - 2	
2. Microcomputer (general office)														
3. Fork Lift Truck														
4. Guided Missile														
5. Electronic Countermeasure Equipment														
6. Paper Towel Dispenser														
7. Pneumatic Chisel														
8. Floating Drydock														
9. 16mm Film Projector														
10. Cold Food Counter														
11. Submarine Periscope														
12. Filing Cabinet														
13. Sandpaper														
14. Aircraft Gunnery Fire-Control Embedded Computer														
15. Bottled Salad Dressing														
16. Nuclear Reactor														
17. Semiconductor Assembly														
18. Shipboard Washing Machine														
19. Flourescent Light Tube														
20. Pneumatic Tire (non-aircraft)														
21. Micrometer (general purpose)														
22. Flat Washers														

FIGURE 1

Table II

Selected Characteristics

Complexity
Customization
Maintainability
Unit Cost
Documentation
Item Attention

Resultant Classificatory Scheme

Figure 2 presents the classification scheme resulting from the survey and cluster analysis. The six attributes listed along the vertical axis are those which were determined to contribute the most to the definition of the sample goods and the five categories.

Labels were assigned to the five categories shown across the top of the model to enhance the scheme's ability to convey the meaning of the five groups. Although an individual might not recall how each of the attributes vary across the groups, an appropriate descriptive label summarizes the basic properties of the category.

Since this research effort has been based on classifying goods from a simple to complex spectrum, the first and last categories were labelled as such respectively. The middle group was labelled "Moderate" because the characteristic descriptions were all of a medium nature. Group two was labelled "Basic" to indicate the transition from a simple item to one that is more involved in terms of the attributes. The "Advanced" category label is applied to the fourth group to indicate that constituent objects are increasingly more complicated than the "Moderate" group. They are, however, distinct from the last category in that their degree of complexity is lower.

Classification Process

Beginning with the six attributes, their definitions and scales, the classification process could begin with a survey similar to the one conducted for this research effort. Respondents would be asked to score a good or goods in relation to the six characteristics. Next the data would be averaged to arrive at a single value for each attribute for each good.

Finally, the grid in Figure 2 would be used as the mechanism to display the average scoring values thus classifying the good in a particular category. Numeric values would be listed in the "Avg Value" column and a "+," "0," or "-" could be used in each of the characteristic versus category cells.

A "+" would be used to symbolize a score that tended to fall near the upper end of a category, "0" near the middle, and "-" towards the lower end. Symbols rather than numbers are used to enhance the model's capability to show the degree to which the good exhibits certain characteristics.

Figures 3 and 4 provide examples of how the scheme graphically illustrates the categorization of different goods from the research data. In Figure 3, sandpaper falls on the lower end of the simple category for each attribute as well as on an overall basis. In contrast, the microcomputer in Figure 4, while overall a moderate type good, exhibits some characteristics more typical of other categories.

	Avg Value	Simple (1.00-1.80)	Basic (1.81-2.60)	Moderate (2.61-3.40)	Advanced (3.41-4.20)	Complex (4.21-5.00)
Complexity						
Customization						
Maintainability						
Unit Cost						
Documentation						
Item Attention						
Overall Score						

KEY:
+ : UPPER END OF THE CATEGORY
0 : MIDDLE OF THE CATEGORY
- : LOWER END OF THE CATEGORY

FIGURE 2
Classification Scheme

Good: Sandpaper **N =54**

	Avg Value	Categories: Simple (1.00-1.80)	Basic (1.81-2.60)	Moderate (2.61-3.40)	Advanced (3.41-4.20)	Complex (4.21-5.00)
Complexity	1.04	-				
Customization	1.15	-				
Maintainability	1.02	-				
Unit Cost	1.00	-				
Documentation	1.00	-				
Item Attention	1.11	-				
Overall Score	1.05	-				

Figure 3
Classification of a Simple Good

Good: Microcomputer (general office) **N =54**

	Avg Value	Simple (1.00-1.80)	Basic (1.81-2.60)	Moderate (2.61-3.40)	Advanced (3.41-4.20)	Complex (4.21-5.00)
		Categories				
Complexity	3.81				0	
Customization	2.19		0			
Maintainability	2.63			-		
Unit Cost	2.94			0		
Documentation	3.07			0		
Item Attention	2.89			0		
Overall Score	2.92			0		

Figure 4
Classification of a Moderate Good

Benefits from Using the Proposed Taxonomy

The proposed taxonomy could be a valuable tool for the practitioner, policy maker, and the researcher. One of the major benefits from using the proposed classification scheme could be in the staffing function of a procurement organization. Several members of both the expert panel and the scoring group indicated that the scheme could be used to correlate the characteristic level of the goods with a buyer's capability.

One respondent related that the scheme may have value in segregating goods within commodity type. Too often, manpower requirements at the field contracting level are based on commodity type with little consideration given to the wide range of differences between the goods within a particular commodity. This individual used an example where the requirement for computers were all treated alike. There was no latitude for recognizing those buys that were highly technical and incorporated many of the characteristics described in this research.

Another potential benefit from using such a classification scheme could be in the area of contracting laws, regulations, and procedures. After classifying a sufficient number of goods, patterns or trends may result that will allow for additional streamlining of the policies and procedures for certain categories. Whereas previously, the distinction has been based more on commodity type, now the perspective would be broader and ensure consideration of more goods.

Ultimately, the greatest advantage could be an increased use of commercial products. Within the expert panel group, several members felt the Government must rely less on developmental items and more on commercially-available goods. This classification scheme may highlight how more goods could be purchased commercially. By more closely identifying a good's characteristics, commercial substitutes to Government development may become more apparent.

CONCLUSION

This paper has discussed the need for classifying the goods the Government buys on a basis other than commodity type. The proposed taxonomy challenges the classifier of Government goods to look beyond physical differences. To those involved in the procurement process, i.e. legislators, policy-makers, and practitioners, the emphasis should focus more on those attributes that impact the buying process. This classification system offers a structured approach for evaluating and categorizing goods in a potentially meaningful manner.

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ALTERNATIVE DISPUTE RESOLUTION IN GOVERNMENT CONTRACTS: AN ALTERNATIVE VIEW

Robert E. Lloyd

ABSTRACT

One of the most highly publicized innovations in Federal acquisition in recent years has been the development of methods of alternative dispute resolution (ADR) to handle contractor claims. Techniques such as the minitrial have been used on several occasions to resolve Federal contract disputes. Unfortunately, many practitioners have seized upon ADR as the solution to clogged dockets without fully analyzing the unique environment in which these disputes arise.

While the potential exists for ADR to make a significant improvement in the current case load at Federal agency boards of contract appeals (BCA's) and the Claims Court, this paper analyzes how some of the basic features of the Government contracting system and ADR itself mitigate against widespread success of ADR in public contract disputes. The paper argues that, as a practical matter, ADR's lack of widespread use is a direct result of disincentives in the current acquisition system. While the trend toward informal settlement has its merits, this movement should more properly encompass disputes that occur before contracts begin, as bid protests have become a major source of dysfunction in the administration of Federal programs.

INTRODUCTION

The great expansion of activity by the Federal sector in the past three decades has occurred not primarily by increasing the Government workforce, but instead by relying on contractor support, the so-called "shadow Government," to accomplish agency missions.[1] As greater attention has been paid to the public contracts arena, focus has naturally shifted to the burgeoning litigation related to contract performance. When the Contract Disputes Act was passed in 1978, Congress spoke of the goal of "expeditious and inexpensive resolution of disputes."[2] Likewise, when the Federal Acquisition Regulation was implemented in 1984, it included a section encouraging informal resolution of disputes by negotiation.[3] Regrettably, this promise of amicable settling of contract disputes did not prevent the thousands of appeals to BCA's that have been filed since these rules were issued.[4] Instead, agencies have sought to break the deadlock of contract claims by developing a variety of ADR procedures.

AVAILABLE TECHNIQUES

An impressive array of ADR techniques has been created to give agencies and contractors a means of settling contract disputes without resort to adjudication. The Armed Services Board of Contract Appeals (ASBCA) encourages three primary ADR methods,[5] the minitrial, the summary trial with binding decision, and the settlement judge. The most prominent of these is the minitrial, which is not actually a trial at all, but a structured process for continuing the negotiations that failed to produce an agreement on the initial claim. In a minitrial, each party presents an abbreviated version of its position to a neutral advisor who may be either appointed by the BCA/court or selected by mutual agreement of the Government and the contractor.

Although the precise format is determined by the parties, typically the minitrial features presentations limited to the principals of either side, rather than persons directly

side, rather than persons directly involved in the original dispute. Each side has an equal, brief amount of time to present evidence without the trappings of customary judicial proceedings. The neutral advisor will then issue a non-binding opinion on the case, or assist in settlement negotiations between the contractor and the Government, but in either case, the resolution must be approved by both parties. The Navy, Army, NASA, and Department of the Interior have all reported success in using minitrials, and the U.S. Claims Court also encourages this process. [6]

A more conclusive version of the minitrial is also available, known as the "summary binding ASBCA procedure" or "summary trial with binding decision," in which the disputants agree to an abbreviated presentation before a board judge. In this form, the scheduling of an appeal is expedited, and the parties try their appeal informally, with modified legal procedures. The process concludes with a summary decision from the bench, which may be simply a one sentence judge's decision on whether the appeal is sustained or denied and the dollar amount. The parties agree in advance that the decision may not be appealed (except for fraud), nor may it serve as precedent in other cases.

The latter technique is also available in a non-binding form whereby a settlement judge is provided from either the ranks of the BCA or its hearing examiners to help facilitate settlement. By discussing the case in depth with such a third party who possesses the requisite position of authority, settlements may result from this independent assessment of the strengths and weaknesses of each side. The settlement judge's recommendations are not binding, but by giving the parties a preview of the likely results of a trial, this method offers an opportunity to resolve the claim in a prompt and cost-effective manner.

A further ADR method is mediation, whose application to Federal contracts is new. The mediation session consists of a joint statement of the parties as to the facts and issues, followed by a 10 page brief by each side summarizing its position. A mediator then meets separately with each party, followed by a conference between the principals and counsel of each side. A settlement agreement resulted from this technique in a recent Interior Department construction contract claim.[7]

Additional ADR methods are employed in other fields of Government litigation, most prominently arbitration; however, the use of arbitrators has been clouded by Constitutional questions and was opposed by the General Accounting Office for many years.[8] Nevertheless, a full range of options is available to litigants to resolve Government contract disputes through non-judicial means. The question is whether this amounts to much hope for reducing the bulging dockets at the courts and BCA's.

SOURCES OF OPTIMISM

Discussions of ADR in Federal contract disputes have often been nearly unbridled in their optimism. In general, ADR advocates promote ADR chiefly for its alleged efficiency attributes. Minitrials have been said to have saved upwards of $1 million on a single Federal contract dispute.[9] Frequently, the only concern in articles on ADR in Government contracts is the desire to save money. This focus should not be surprising or disturbing, since most Federal procurement disputes focus on money, rather than the problems of society at large or lasting interpretation of contract terms.[10]

ADR offers the chance to resolve claims without the costs and delays involved in traditional appeals. In doing so, ADR may actually improve the quality of justice available to

contractors, if the current delays in obtaining appeals decisions mean that justice is denied. Some contract disputes have taken as long as 25 years to be decided.[11] For the small business owner who lacks the means to carry through a lengthy BCA appeal, the availability of ADR may mean that, for the first time, he or she may expect a contract claim to be considered in an speedy fashion.

Any objection that ADR is "second-class justice" relegated to those who cannot afford costly legal support can be countered by the fact that all ADR methods now used in Federal contracts are strictly voluntary and are not imposed by any court or BCA. Although there has been mandatory use of abbreviated legal process in some other areas of litigation,[12] this has not been the case in Government contracts. To its credit, ADR is even said to engender the noble qualities of conciliation and reducing alienation between litigants.[13] On the surface, the optimism surrounding ADR thus seems to be well-founded. The various approaches to ADR share one thing in common, however: they operate in a Federal contracting system which has an incentive structure that is quite different from other areas where ADR has been applied.

REASONS FOR DOUBT

There are three basic elements affecting Federal acquisition that create structural problems which work against the success of ADR: the continued performance rule, the second-guessing problem, and the supply/demand effect. First, a basic flaw in relying on ADR to resolve contract disputes is that all Government contracts require the contractor to continue performance in the event of a dispute, thus diminishing Government agencies' need for prompt resolution. [14] Shedd points out that this is no guarantee that a contractor will perform, especially if the Government in its conduct breaches the contract. [15] Nevertheless, as a practical matter, the risk involved for the contractor is too great to amount to much serious consideration of non-performance when a dispute occurs. Although it has been said that when the Government steps down from its position of sovereignty and enters the marketplace, it must submit itself to the same laws that govern individuals,[16] when faced with a contract dispute, contractors know well the Government's sovereign capacity and, mindful also of the need to maintain good relations for the sake of future business opportunities, a firm can, in most cases, be expected to perform as directed.

In addition, settlement of disputes by non-judicial means tends to draw criticism and "second-guessing" by those concerned that out-of-court settlements may be too generous or undeserving. Settling a dispute may mean that the contracting officer must risk an Inspector General investigation, such as that which occurred after the second major minitrial in Government contracts.[17] It is much safer, from the agency's standpoint, to avoid the risk and let the court or BCA decide.

It has also become an unfortunate fact that a decision on a contract claim issued by a BCA or court judge has more salience that the same decision reached by anyone else. Commentators have noted the increasing judicialization of administrative law,[18] despite the fact that executive agencies were created precisely to avoid the sort of complex litigation that prevented efficient administration of the law by the other branches of Government.[19] Predictably, the combined weight of these two disincentives to ADR has produced little result in reducing contract claims. Since 1979, only an estimated 22 Government contract disputes have been resolved by ADR, while the ASBCA alone receives approximately

2,000 new appeals each year.[20]

A recent incarnation of ADR legislation, H.R. 2497, the Administrative Dispute Resolution Act,[21] allows arbitration to be used in settling disputes, but the arbitrator's award may be vacated by the head of the agency. This "escape clause" simply perpetuates the incentive problem in getting agencies to agree to and abide by ADR procedures, even though it may solve a constitutional question regarding the legality of binding the Government to the decision of a private party, which has been a source of controversy.[22]

Judge Posner has identified a further practical difficulty that would present itself even if ADR did prove successful in becoming a widely used tool for resolving disputes. By lowering the cost of filing and pursuing a claim, ADR could cause an increase in the number of claims, assuming that the normal rules of supply and demand are present.[23] Hence a word of caution is in order for those who tout the prospects of ADR for improving Federal contracting. Moreover, the introduction of ADR once an appeal has already been docketed at a court or BCA may be too late; by that time, significant litigation expenses and delays have already been incurred. This is one of the principal limitations of ADR in general, along with the fact that the use of ADR does not guarantee settlement and can itself lead to costly delays.[24]

I have elsewhere developed a theoretical justification for ADR in Federal contract in terms of satisfying the needs of justice.[25] The likelihood of success for ADR, however, does not hinge on such abstractions, but instead will depend on more practical concerns. Given the environment in which Government contracting occurs, it is not surprising that the statistical results on ADR usage have been so meager. The weak response to ADR by contractors has come even after extensive outreach efforts by the Government to make ADR readily available. For example, the Navy offered 58 contractors the opportunity to resolve their claims using summary binding procedures, but only six accepted, perhaps out of suspicion regarding the Government's motives or because acceptance of the procedure required a waiver of appeal rights. [26] The ASBCA reports mixed results from using ADR.[27] It is now becoming apparent in private law also that the vast majority of companies do not use ADR, and the results have been ambiguous for those who have done so.[28]

Publicity about ADR in public contracts has been widespread. In addition to Federal agencies' own efforts to promote ADR, from February 1989 to July 1990 there were 15 articles on ADR published in <u>Federal Contracts Report</u> alone. Despite the fanfare, though, the number of contract appeals has continued unabated. With such scanty evidence on ADR's behalf, it is hard to express much optimism for its success.

THE FORGOTTEN PROBLEM

Despite the alleged urgency to use ADR to alleviate excessive caseloads at the BCA's and courts, the attention given to contract performance disputes is misguided. The most alarming increase in dispute activity has occurred in the stage before contracts are even awarded. Bid protests have become a serious obstacle to a Federal agency's capacity to accomplish its mission on a timely basis using contractor support. Ironically, ADR has largely ignored this problem.

The most serious concern is in the award of Federal contracts for computers (automatic data processing/ Federal information processing resources), which are subject to protests before the General Services Administration's Board of Contract

Appeals (GSBCA). The GSBCA protest system has established an absolute standard for awarding ADP/FIP contracts, since by law the board must review any allegation that a contracting officer violated a statute or regulation and suspend the agency's procurement pending a decision.[29]

Just as the Government has an incentive not to settle post-award contract claims by negotiation, due to the continued performance rule, so do disgruntled contractors have a clear invitation to file bid protests to stop a contract, regardless of the merits of their position. This incentive is especially large for incumbent contractors, who may use this technique to obtain an extension of their contract pending resolution of the protest. Understandably, the temptation to extract such economic rent [30] from the Government by protesting with virtual impunity can be too great for some firms to resist. Consequently, the GSBCA, which prior to the Competition in Contracting Act of 1984 had no authority to hear bid protests, received 1,030 protests between January 1985 and June 1990. [31]

The specter of frequent delays of contract awards has caused Federal agencies to consider settling protests away from the GSBCA's domain, as the Federal Circuit has ruled that the GSBCA may not interfere with protest settlements.[32] Some settlements have involved payments to protestors, thus prompting charges of "protest for profit" or "Fedmail," [33] a development which has led to the introduction of a bill in Congress to mandate disclosure of the terms of bid protest settlements. Ironically, in the same month a bill was introduced to encourage the use of ADR and protect the confidentiality of settlement discussions.[34]

In addition, GSA itself has issued guidance in the Federal Information Resources Management Regulation to encourage the resolution of bid protests at the agency level, such as by a review board or other layer of review, without resort to the GSBCA or another protest forum.[35] Nevertheless, this procedure has been criticized for "second-guessing" contracting officers. Others argue that a further review will be meaningless if it involves simply asking the original decision-maker to reconsider.[36]

Despite such efforts by GSA at a time when ADR has been in the forefront of public attention in Government contracts, the trend in bid protests has been in the opposite direction, toward more judicialized procedures. This is nowhere more evident than at the General Accounting Office (GAO), which received nearly 3,000 protests in fiscal year 1989.[37] GAO amended its previously informal bid protest regulations in 1987 to make its proceedings more court-like by providing for a fact-finding conference with testimony of witnesses under oath.[38] GAO planned even further actions at variance with the goals of ADR by proposing to implement additional hearing rules whose purpose is to allow for more formality in its hearings.[39]

Though GAO has declared that its bid protest system for resolving preaward disputes was enacted by Congress "for the purpose of providing inexpensive and expeditious resolutions of protests on a governmentwide basis,"[40] the recent trend toward more legalistic process speaks otherwise. Another paradox is that GAO's own regulations provide that, if an agency has determined to continue with the award of a contract despite a pending protest that is eventually sustained, GAO will make its recommendation for relief without regard to any cost of disruption to the agency.[41] While this is intended to give the contracting agency an incentive not to abuse the protest

system, the explicit disregard for the costs involved seems inconsistent with the overall goal of efficient dispute resolution.

The same Government thus espouses two different views on the importance of settling contract disputes without the trappings of traditional adjudication. From a broader legal perspective, these developments in the Federal bid protest system are even more puzzling. The protest system is based on the concept of private parties suing the Government to maintain justice, but elsewhere in the law, the trend in recent years has been away from this "private attorney general" model of enforcing public law and regulation.[42]

CONCLUSION

It is now routine practice for some BCA's to give litigants written encouragement to use ADR when they file their appeals.[43] This gesture may be in vain, however, because of the systemic biases against informal settlement in Government contracting. Furthermore, the Government has sent mixed signals to industry. On the one hand, Federal agencies solicit contractor participation in ADR, while at the same time, the Government has ignored ADR's potential in the contract award process by increasing the legal formalities of bid protests, even as protests have become as voluminous a source of disputes as contract claims.

If ADR is to make a significant contribution to improving the Federal acquisition system, it should embrace all forms of contract disagreements, not simply claims arising during contract performance. The grave concerns expressed about the current, disruptive bid protest system, which has created a rent-seeking environment, should not be ignored by those who promote ADR. James Buchanan argues that reform in a rent-seeking society will not be achieved by incrementalism or pragmatism, but rather by thinking in terms of general constitutional changes in the entire structure of social and economic institutions.[44] Accordingly, unless the structural and incentive problems present in the Federal contracting system are addressed, there will be little hope for reducing the number of contract disputes and enhancing relations between Government and industry in the future.

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21. Congressional Record-House, June 5, 1990, pp. H3152-H3157, and October 26, 1990, pp. H12967-12972.

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25. Lloyd (1990), pp. 104-107.

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27. Federal Contracts Report, August 28, 1989, p. 405.

28. Rudlin and Shebelskie, pp. 2-3, 2-30, 2-31.

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NEED FOR ACQUISITION RESEARCH

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ABSTRACT

Without question there is a continuing need for acquisition research especially, concerning weapon systems. Because of the differences in the acquisition cycle for DoD contractors, we need to perform more "pin-point" research on specific acquisitions problems.

There have been a number of successes the DoD Weapon System Acquisition area in the last five years. Many would say that the implementation of competition in major systems acquisition was a glowing achievement. Because of successful implementation of competition in DoD, Congress has authorized and funded many needed new programs.

Acquisition Streamlining may be defined in a broad sense as a process of acquiring DoD weapon systems in a smarter or wiser manner. Thru "pinpoint" acquisition research, we can work towards successful acquisition streamlining.

There are a number of areas that could be considered candidates of "pinpoint" acquisition research. One such area is the concept of compensating DoD contractors based on their performance rather than their cost expenditure rate. Research concerned increased use of CPAF Contracts may be worthwhile.

We need to look at best value "awards" as a move to buying DoD requirements in a smarter manner. Research in TQM or quality set asides may be worthwhile. We need to take a serious look at the acquisition of less expensive weapon systems. A present and/or planned force structure will not support $600 million Destroyers or $200 Advanced Tactical Fighters. The concept of a family of weapons might be considered. Other countries are considering diesel submarines for coastal defense; perhaps we should do the same.

Recent experience has shown that we need to move away from fixed priced development contracts. If neither party has a good fix on what the development cost will be, a CPFF or CPAF vehicle may be more appropriate. We need to look into cost estimating for development efforts and the optimum contract type. Too many important development contracts are being cancelled.

Finally, we need to conduct research concerning the acceptability of commercial or Non-Developmental items for DoD use. The Sperry MCS-2B Satellite Navigational System is just one example of proven commercial items. We need to look at how our commercial counterparts acquire and maintain their major systems.

It is suggested that DSMC publish a list of viable research topics that will lead to further successful Acquisition Research Symposiums.

INTRODUCTION

There is a continuing need for acquisition research both in the Department of Defense and the federal government. Dr. Edward Kaitz, a frequent supporter of the Defense Systems Management College suggests that we perform acquisition research to (1) effect policy, (2) educate key people, (3) establish corporate memory and (4) build up a usable data base.[1] Dr. Kaitz would say that acquisition research is different from non-defense or academic research because the acquisition cycle has a life of its own. Marketing functions of a defense contractor are arranged around the acquisition cycle and financial policies are developed around mandated cost accounting rules and other government specified financial practice.

Finally, Dr. Kaitz would say that regulations surrounding the acquisition cycle exist because they deal with an "artificial world" as opposed to a free market world.[2] The process of acquisition research is somewhat straight forward, however. We develop a statement of the problem and perform some library research, but in a different manner. We are not looking at theorems but at problems. We move on to develop a hypothesis to determine the type of data needed and attempt to gather good data. It may be necessary to get into the field to see what we are researching and then write up our findings.[3]

In this paper, I will first look at some acquisition successes and then attempt to identify a few general areas where I believe "pin-point" research will help alleviate recurring problems. Finding solutions will not be easy, but we need to start now.

SUCCESSES

There have been many successes in the DoD Major System Acquisition Area. In the success category, we can include items like competition. Although many of us were skeptical about the implementation of competition in the major systems acquisition arena, we can generally say that competition has resulted in better pricing and greater cooperation by Congress in the approval and funding of major systems. Competitive Full Scale Engineering Development (FSED) was somewhat successful but reduced acquisition funding is forcing us away from this approach. The jury is still out on the dollar savings from competitive systems development, but wonderful technology advances have been achieved. An example would be the development of air cushion technology in the competitive Air Cushioned Landing Craft (LCAC) Program. In the last few years, we have used a new type of contract, the Fixed Price Incentive/Award Fee (FPI/AF) vehicle for the DDG-51. It was used for DDG-51, with some cost growth side effects, because a very good target cost could not be developed at time of award.[4]

The practice of continuing to award followship contracts to active yards has proven valuable both from a cost and a quality point of view. This practice is not new, but it has been successful.

Efforts at commercialization have been met with some resistance from government employees that have lived with MILSPECS all of their lives. The Sealift Support Ship Program has been successful based on using existing commercial hulls and proven commercial designs to deliver much needed sealift capacity to the U. S. Navy.

The process of contract streamlining after award has been tried in a number of areas, sometimes with better success than others. The Navy T-45 Training Aircraft entered Full Scale Engineering Development (FSED) using a modified existing British aircraft design and Rolls Royce engines. During FSED, in an effort to reduce cost, the Navy agreed to (1) use existing British drawings and documentation , (2) use a derated existing Rolls Royce engine and (3) to build two versus four prototype planes for testing.[5] Although this streamlining effort reduced the cost of the FSED Contract by almost $400 million, the two test aircraft did not achieve service specifications during flight tests. [6]

There are a large number of possible areas of improvement than can be made in DoD Weapon System Acquisition. Many of the papers presented here today may speak to these improved areas or to the need for continuing research in order to further our improvements in these areas. The purpose of my paper, however, is to place a wake-up call for more specific or "pin-point" acquisition research to be conducted by the Defense Systems Management College, the Navy Postgraduate School in Monterey, California, the Air Force Institute of Technology at Wright Patterson AFB and the many U.S. Colleges and Universities offering courses and performing research in the area of Procurement and Contracting.

ACQUISITION STREAMLINING

At this point I would like to introduce a new definition for acquisition streamlining as an

area in which additional research needs to be done. I define "Acquisition Streamlining" as the process of buying DoD requirements, especially weapon systems, in a smarter or wiser manner. In order to accomplish this, we need to perform research on (a) how to reward contractors based on their performance, (b) how our commercial counterparts manage their major acquisition process and (c) deriving "lessons learned" packages from successful buying and program offices in the Department of Defense. We need to develop and build an acquisition library and then come up with possible solutions for testing in specific locations, to determine if proposed acquisition solutions have merit.

In this paper, I will identify a few general areas where I believe that "pinpoint" acquisition research will help alleviate recurring problems.

AREA 1 Compensate Contractors Based on Their Performance.

Many contractor look upon the FF in Cost Price Fixed Fee (CPFF) Contracts as "fire and forget." After the CPFF contract is awarded, the Contractors will earn their fee whether they perform the contract in an outstanding manner or a poor manner. Many government organizations will tolerate poor performers because they find the Termination for Default procedure too difficult to substantiate or the Termination for Convenience procedure too expensive. By using Cost Plus Award Fee (CPAF) Contracts, the federal government and DoD can reward the contractors for superior performance by providing more fee or profit on the contract. Poor contractors can be penalized with reduced fee, which will get the company's attention. Research can be performed on successful CPAF Contracts to look at their structure and how they operated. Both the DoD and DoD contractors can gain/profit from the concept of rewarding contracts for superior performance.

AREA 2 Move to Best Value Awards

J. Edwards Deming, the developer of the Total Quality Management (TQM) Movement in Japan and the U.S., has established what he calls his fourteen rules of quality management. Rule number four states "End the Practice of Awarding Business of Price Tag Alone."[7] Although this rule may seem unusual to some of us in the government, U.S. industry has, in fact, been following this route for many years. Deming advises that a buyer should establish a long term reciprocal relationship with vendors that provides high quality products delivered on time and at a fair and reasonable price. We would agree that this rule would, of course, depend on the nature of the procurement. For products as basic and proven as bolts or tires, a low fair price should be the determining factor. However, for much of what we buy in DOD, quality and performance and not low price may be the best solution to a difficult acquisition situation. Relative to quality, the Office of the Secretary of Defense recently issued a policy memo stating that professional services in the DOD should be acquired on the basis of best value.[8]

My point here is that we need to take a look at best value for a number of our less common buys, including small weapon systems. How about setting aside acquisitions for TQM qualified contractors, as a way to encourage more DOD contractors to develop TQM in their plants. Or, how about set asides to "Quality" contractors or contractors who consistently provide high quality on time and at fair and reasonable prices.

AREA 3 Need to Acquire Less Expensive Weapon Systems

The truth of the matter is that we cannot afford extremely expensive weapon systems. A $600 million Destroyer and a $200 Advanced Tactical Fighter may be beyond our budget, especially if we are not to disassemble our existing force structure. Force structure considerations should help to determine how much we can spend for new weapon systems. We can no longer afford open-ended procurements.

One area for research may be that of a "Family of Weapons" Concept. The U.S.

Army has been doing this with a family of vehicles. The French and Russians use a family of weapons approach continually through their greater reliance on an evolutionary versus a revolutionary design process. To some degree, this has been done with the DDG-51 and CG-47 class of ships. Each class uses the basic hull and power plant derived from the 30 ship DD963 Spruance Class Destroyer Acquisition Program. In a sense, the two newer classes of ships (CG-47 and DDG-51) represent an upgrade of a previous design. Given budget restrictions, might not this approach be used with the F14 Aircraft. Existing assembly lines or shipyards could be kept open over longer periods of time, with significant savings accruing to the DOD. The services have started to look at this concept.[9] The concept may result in some unused factories closing because of longer runs at other factories, but such a price may well be worth paying.

AREA 4 Acquire Less Complex Systems

Another area of research may be in looking at the development and deployment of less complex weapon systems. For financial and other reasons, the British and our European Allies use smaller Frigates for surface force warfare missions rather than larger destroyers. Despite their smaller size, they appear to be mission effective. A classic case appears to be the use by other navies of diesel submarines for coastal defense missions. In this role, they appear to be as effective as the far more expensive nuclear submarines. This approach would require some heavy duty analyses, but there may be some substantial pay-off here.

AREA 5 Move Away from Fixed Priced Development Contracts: Move to Cost Plus Fixed Fee or Cost Plus Award Fee Development Contracts.

We have seen that the use of a firm fixed price contract for the development of major weapon systems is fraught with danger. The Large Amphibious Assault ship (LHA) Total Package Contract of 1970 was a Fixed Price Redetermination type buy that ended in a billion dollar claim. Recently, the Fixed Price P-7 Antisubmarine Warfare Development Contract was terminated for default by the Navy after the Lockheed reported losing $300 million.[10] There have been problems with the DDG-51 Contract, since it was awarded as a Fixed Price Incentive/Award Fee Type Development contract.[11] The Navy A-12 and Air Force C-17 are other examples of Fixed Price Development contracts that are in trouble. The problem here is that it is extremely difficult to award a fixed price development contact where neither party has a good estimate of the cost of the work to be performed. There should be composite information in industry regarding the historical cost of the development of a new aircraft or ship. This information, if it exists, is not being well used to price fixed price development contracts.

The results of present fixed price development is delay and cost growth that could or does lead to termination of the program and/or substantial priced claims. History has shown that great success can be obtained in major development contracts through the use of Cost Plus Award Fee Contracts. The AEGIS Cruiser Program (CG-47) is a case where the Navy achieved a lead ship completed on time and within target cost using the right contractual vehicles.[2] We need to develop a book of lessons learned and try to award development contracts with viable contractual vehicles. Someone needs to do research and develop a composite System Contracting Lessons Learned Report.

AREA 6 Need to Move Towards Buying More Good Commercial Items or Non-Developmental Items (NDI).

Although there is a large effort now underway to buy more commercial and NDI items, many government employees, especially in the technical ranks, do not feel comfortable with these approaches. In all fairness to government engineers, there is a certain loss of configuration control when you move to a commercial or NDI item. However, research could be done to show

the many successful and economical cases of commercial items and NDI in DoD. One example may be the Training Craft for the U.S. Navy Academy, which were procured with all commercial type equipment that could easily be supported commercially in Annapolis, Norfolk, Baltimore or Newport, or other commercial ports where these small craft operate. The Army and Marine Corp are using a modified version of the Chevy Blazer for off the road vehicles. About 1000 commercial ships use the Sperry MCS-2A or MCS-2B Satellite Navigational System, which is supported logistically in most all large ports in the world.[13] This efficient and durable system is about a third of the cost of the Navy's MILSPEC shipboard Satellite Navigation System. Granted that shock hardening and other features may be important to the Navy, we still need to look at commercial equipment that is successfully used by our commercial counterparts. Some research needs to be done on the successful use of commercial and NDI items by DoD and lessons learned in these areas need to be shared.

CONCLUSION

In conclusion, the above ideas represent just a few areas where acquisition research can be directed with the strong possibility of improving the acquisition process. DSMC is presently collecting information regarding ongoing acquisition research being performed by either government, universities or industry. This effort is sincerely welcomed. I suggest that once a year, about six months before the annual Acquisition Research Symposium, interested parties gather at DSMC or AFIT or Monterey to consider subjects that should be researched, and that such a candidate list for acquisition research be sent by DSMC to Universities and Agencies and others so that structured, purposeful research can be conducted and reported upon annually.

ENDNOTES

1/ Edward Kaitz. Unpublished Paper. Marymount University, Arlington, VA., June 1990, p. 1.

2/ Ibid., pp. 2-5.

3/ Ibid., pp. 6-9.

4/ Naval Sea Systems Command DDG-51 Contract Nr. N00024-84-C-2228 dated August 31, 1984.

5/ Naval Air Systems Command T-45 Training System Program Streamlining Update, January 15, 1986, p. 274/0004.

6/ Edward H. Phillips, "Team Correcting Deficiencies in Navy's T-45A Training Aircraft" Aviation Week, Vol. 131, October 30, 1989, p. 16.

7/ Chris Henderson, A Review of Management Principles, Graduate Research Paper, Marymount University, April 13, 1989, p. 11.

8/ Donald J. Yockey, "Source Selection Procedures for Professional and Technical Service Contracts", Office of the Under Secretary of Defense for Acquisition, May 6, 1990, pp. 1-2.

9/ Molly Moore, Washington Post, No. 34. January 8, 1991, p. A6.

10/ "Lockheed Learns Cost Lesson in Systems Design", P.C. Week, January 29, 1990, p. 1.

11/ DDG-51 Contract.

12/ Naval Sea Systems Command CG-47 Contract Nr. N00024-78-C-2316 dated September 1978.

13/ Telephone Interview with Mr. George Tsirimokos, Sperry Marine Corporation, Charlottesville, VA, 10 January 1991.

A STUDY OF THE USE OF COMMERCIAL PRACTICES FOR DEFENSE ACQUISITIONS

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ABSTRACT

There is general acceptance of the notion that adoption of commercial practices can improve defense acquisition. However, there is a lack of concise, readily available information and guidance specifically designed with the objective of enabling DOD program managers to adopt them. To help remedy this, the Defense Systems Management College (DSMC) contracted with ANSER for a study of commercial practices with the goal of identifying those that may be useful to DOD program managers and documenting the study results in a guidebook.

Usual commercial acquisition practices, procedures, and contracts differ from those used by the Government and in many instances differ from those used to sell to the Government. For the study, commercial practices did not include those practices necessitated as a result of selling to the federal Government since they would probably not exist in the absence of Government buying activities. The following working definition of commercial practices was used for the study:

> **Commercial practices are** techniques, methods, customs, processes, rules, guides, standards, etc., **normally used by business, but not normally by the federal Government.**

A limited number of commercial practices and inhibitors will be described in this paper. A full discussion of them and of other aspects of the study, such as the affects of a specific inhibitor on a commercial practice or traceability of inhibitors to sources in regulations and/or public law, will be included in the guidebook scheduled to be released by DSMC in late 1991. It is intended to be used in DSMC courses to help educate DOD program managers in adopting commercial practices. However, the entire acquisition community may benefit from using the guidebook.

INTRODUCTION

Background

The 1986 Packard Commission Final Report and the Defense Science Board 1986 Summer Study concluded that the use of commercial practices in the DOD acquisition process had a potential for saving money. The 1986 Defense Science Board said, "The Program Manager should have discretionary authority to use commercial practices and products when appropriate." (1:62)

Standard commercial acquisition practices differ from those used by the Government. Different goals and objectives are an underlying cause for the differences in practices between the sectors. For example, in the commercial sector prices are established by competitive demand in the open market, not by cost analysis as is often done when the Government is the buyer.

Another difference is that the Government procurement process is usually stimulated by a Government solicitation to buy rather than by a vendor's offer to sell. The Government says, "This is what I want to buy." Sellers say, "This is what I have to sell." Both approaches require an understanding of customer needs, and both exist in the commercial sector. However, the "buy approach" overwhelmingly dominates the Government sector.

Government needs are usually expressed through specifications or purchase descriptions of end product performance and do not include customer services and other assistance normally offered to buyers in the commercial sector. These are not usually an important factor in most Government buy decisions.

The foregoing examples are only a few of the differences between the Government and private sectors and are intended to only be illustrative, i.e., draw attention to the differences between the commercial and Government sectors. Other differences are included in the descriptions of the commercial practices and inhibitors in this paper and in the guidebook. Thoughtful consideration of them may provide insights into improving DOD acquisitions through adoption of commercial practices.

Commercial Practices Study Scope

The focus of the study was acquisition practices, and its scope was limited to commercial practices potentially applicable to defense acquisition. In this study, commercial practices were considered as those methods and techniques used by firms when acting as buyers rather than sellers in the marketplace. This included practices for projects undertaken by a firm using its own resources and being accountable only to itself and its owners. The study recognized, but did not encompass, the kinds of practices identified in the Navy "best manufacturing practices" program (Office of the Assistant Secretary of the Navy, Shipbuilding and Logistics). The same is true of the "best practices" identified by the Rittenhouse Acquisition Streamlining Task Force, Defense Science Board Study 1990-1991.

Numerous studies, reports, and other references were consulted during the study, and on a non-attribution basis, many spokespersons were interviewed individually and as representatives of Government organizations and contractor associations and groups. Their assistance and views were very helpful throughout the study.

Advantages in Using Commercial Practices

The following were often mentioned as potential advantages of adopting commercial practices: cost savings on initial acquisition and throughout the life cycle, higher quality, improved technology, enhanced support capability, socio-economic benefits, shortened schedules, and enhanced performance. With the inherent flexibility of commercial practices, adoption of some may be a partial solution to a program manager's dilemma of balancing the need to provide fair and equal opportunity to sell to the Government with the need to extract "best value" from the process.

Contrary to popular belief, adopting commercial practices is not a panacea. There are no guaranteed advantages in adoption. Common sense must be the watch word in adopting any practice, commercial or non-commercial. The true value of adoption can be seen only after examination of its situational advantages and disadvantages.

Disadvantages in Using Commercial Practices

Generally, the disadvantages of adopting commercial practices are rooted in the inhibitors that require management attention to cope with and that might entail programmatic risk through less micro management. Three categories of this type of disadvantage are: quality problems, supportability issues, and socio-economic factors. (2:22)

Some drawbacks in adopting commercial practices for defense acquisition stem from fundamental systemic differences between acquisitions in the commercial and DOD sectors of the economy. Retired General Lawrence A. Skantze provided some insights into the differences in an article he wrote for the *Inside View* column in *Defense News*. He identified the following three characteristics that differentiate defense acquisition from commercial industry:

1. Defense acquisition management as fundamentally a business of risk management

2. Guaranteed systemic funding instability

3. Transitional nature of DOD leadership and the lack of industrial experience in complex technology development (3:28)

A major drawback--or challenge, depending on your view--is the need for careful planning that recognizes the differences between the Government and commercial sectors and a need for a sustained commitment of management energy to prevail in execution. Education and guidance in adopting commercial practices will help, but the process will be difficult and the results not always readily apparent to a short-term evaluation perspective.

Finally, adopting commercial practices might also potentially entail personal liability through failure to comply with legal requirements, particularly those associated with fraud, waste, and abuse.

COMMERCIAL PRACTICES

The commercial practices identified during the study were:

1. User/Customer Communications and Involvement
* 2. Market Research and Surveys
* 3. Best Value
* 4. Supplier Relationships
    A. Limited Competition
    B. Selected Sources and Source Development
    C. Work Continues During Protest Resolution
* 5. Contracting Practices
    A. Standard Form Contract
    B. Standard Purchase Agreement
    C. Volume Purchase Agreements
    D. Contract Types, Terms, Conditions and Incentives
    E. Packaging Practices
    F. Product Acceptance Practices
* 6. Documentation/Specification Practices
    A. Greatly Reduced Documentation (compared to the DOD)
    B. Functionally Specified Requirements
    C. Data Procurement Methods
* 7. Warranties
    A. Types
    B. Service and Administration
    C. Support Practices (Seller Supported)
* 8. Inventory Management and Commercial Distribution Systems

9. Use of Non-Developmental Items (NDI)
10. Programmatic Practices
    A. Commitment to Program Success
    B. Management Emphasis on Outcomes versus Process
    C. Program Stability
    D. Change Management and Philosophy
    E. Schedule is Paramount
    F. Top Management Involvement In Programs
    G. Program Management Authority and Control

* Described in this paper.

2. Market Research and Surveys

Market research and surveys are essential to a firm's survival. They are used to determine the availability of products and sources, the extent of competition, the range of product performance characteristics, market acceptability, current market prices, and the range of available distribution systems and support services. The objective is to determine what is available, or potentially available, to satisfy user needs. (6)

In addition to satisfying buying goals, market surveys are also used to realize seller goals. They not only help ensure best value at the best price, but are used to identify business opportunities (unsatisfied needs) and product acceptance, to establish competitive pricing structures, and to develop product "bundling" and packaging strategies.

Many techniques are employed to keep abreast of marketplace developments. They range from informal practices such as reading catalogues, sales literature, periodicals and reports; listening to sales pitches; and attending trade shows, fairs and symposiums; to formal practices such as conducting studies, interviews, and surveys using sophisticated instruments. Market research is usually a continuous, ongoing activity performed as a normal business activity. Normalizing adoption of this commercial practice in the Government will help it ensure the purchase of good value from responsive, responsible suppliers.

3. Best Value (Lowest Total Overall Cost)

Strictly speaking, the concept of "best value" is not a commercial practice within the definition of commercial practices used in the study. Best value is beginning to be recognized by Government, and in fact the DOD has published a study that describes a best value evaluation process. (5) Although the practice of best value has already been introduced in the DOD, it is new enough and significant enough to be documented in the results of this study.

Best value means making a purchase decision on other than a cost-only basis, which is the usual Government practice. The concept is essentially the application of common sense to the buying process, i.e., consideration of more than price alone in the buying decision. The discussions of "best value" have usually centered on using more than price alone as the basis for purchase decisions. Quality and reliability were two factors most often mentioned to be considered in addition to price, but there is no universally accepted definition of "best value." This is probably partially due to the fact that "best value" is context sensitive, i.e., what it means for one purchasing decision may not be applicable for another decision. Each product is unique, with different circumstances surrounding its

acquisition. Therefore, being flexible, adaptable, and knowledgeable about what is available in the marketplace are necessary prerequisites to making good decisions on "best value." (See Market Research and Surveys commercial Practice above.)

With these caveats in mind, for this study "best value" was defined as:

> **the consideration of all factors** relevant to the usefulness and suitability of a product throughout its anticipated life cycle **in addition to price when making an acquisition decision** or distinguishing between muitiple purchase sources.

Stated concisely, best value is "lowest total overall cost."

Organizations, particularly non-Government ones, are not constrained by rigid rules and can more easily apply common sense, an inherent requirement in adopting or using a commercial practice such as best value. For example, buyers for commercial companies use competition to their advantage, getting maximum value at an affordable price. Their objective is neither lowest price nor maximum performance, but a balance between often unquantifiable, more subjective "value" criteria. Once a buy decision is made in the non-Government sector, it is basically uncontestable by the losing offerors, making best value easier to adopt in the commercial sector than the Government sector.

4. Supplier Relationships

Maintaining good supplier relationships is an important practice in the commercial sector. Commercial buyers seek out suppliers of high-quality, low-priced products and then stay with them as long as the relationship remains mutually beneficial. Commercial businesses avoid suppliers with inconsistent or unsatisfactory records of performance and delivery. They do, however, consider a new supplier if there is potential for a better quality or lower priced product, and if the new supplier is evaluated successfully in terms of stability and quality management practices.

Limiting competition to a few well-known suppliers can help ensure product quality and on-time delivery. A number of large companies have major initiatives underway to reduce their supplier base as a measure for increasing the quality of their products. A supplier's past history of innovation and improvement enables a buyer to take advantage of product improvements with little associated risk. A larger business sometimes works with a supplier to develop it as a new source for a product, thereby establishing a long-term relationship of benefit to both parties. The buyer will have a stable, dependable, high-quality, available-when-needed source of supply, and the seller will have a dependable customer, enabling it to survive through unfavorable business cycles. These relationships also permit work to continue, to both parties' advantage, during dispute and protest resolution. Long-term relationships with specific suppliers can also yield "preferred customer" prices. The benefits of this commercial practice are substantial, but must be weighed against the requirements for competition and maintaining a broad industrial base of able suppliers.

5. Contracting Practices

Commercial firms usually rely on the Uniform Commercial Code (UCC) as a regulatory guideline for general requirements on the standard conduct of

business, and on standard, market-wide contracting practices. As a result, contracts are simple and concise, addressing only the specific requirements of the particular acquisition.

Commercial businesses use standard form contracts, standard purchase agreements, and volume purchase agreements. A standard form contract allows a consistent method to be followed for purchasing similar items. Standard purchase agreements with suppliers allow reordering of stock items at stated price levels without having to negotiate a contract for each order. With a volume purchase agreement, a supplier agrees to give a discount on the normal per-unit price when the business agrees to order a large quantity of the product. These practices enable streamlining of the contracting process to save time and reduce costs.

The commercial sector relies to the largest extent possible on the supplier's standard business practices. The foremost prerequisite is that the product satisfy the buyer's requirements, e.g., form, fit, and function. The commercial buyer does not try to control a supplier's manufacturing, packaging, or quality assurance processes. The UCC is used as industry-wide guidelines on these processes so there is a mutual understanding between the contracting parties.

6. Documentation and Specification Practices

Documentation and specification practices differ widely between Government acquisition organizations and those in the commercial business sector. There are three primary differences: specification practices, data rights, and data delivery. In the commercial sector acquisition needs are usually stated in product terms (e.g., performance characteristics such as a 200 passenger airliner with a cruising range of 2000 miles with the corporation color scheme and logo) and do not include requirements on how to produce an item.

When buying commercially available products, firms normally only receive those documents generally produced with the product, e.g., operator or maintenance manuals. As a rule, suppliers only produce those documents necessary for the routine use of their product, and those are the only ones generally available.

Finally, in the commercial sector the normal practice is for the supplier to retain all rights to the technical data associated with the product. The commercial buyer is only authorized to use the product for its stated purpose and is not provided proprietary data that would enable the buyer to become a competitive producer. Commercial companies with a technological lead in their commercial market are often unwilling to provide proprietary data and risk the loss of a technical advantage even when offered compensation for the potential loss.

The Government can not simply adopt standard commercial documentation and only order commercially available data. It needs to consider all elements of the acquisition equation, from intended use and deployment to the maintenance/support concept, including warranties. What's important to note with this practice is that commercial buyers and users of large systems, such as worldwide airplane fleets seem able to operate with significantly fewer data deliverables than the Government. (See the related description of the Specification Practices inhibitor below.)

7. Warranties

Use of warranties is not a commercial practice per se, since they are used throughout Government. However, a DOD program manager's adoption of existing commercial warranties rather than creating and imposing unique DOD/Government ones is included in the definition of commercial practices. Commercial firms use existing warranties to the maximum extent possible. They need to be evaluated on the basis type, cost, and administration, and the who, what, when, and where of seller-provided service and support. Note that warranties are also listed as an inhibitor because when they are specified and administered in accordance with DOD regulations they may inhibit the adoption of commercial warranty practices. (4)

8. Inventory Management and Commercial Distribution Systems

Inventory management is closely linked to the use of commercial distribution systems. Inventory management in the context of this study means managing stock levels, striving to keep inventory costs as low as possible while meeting schedule/delivery commitments "just in time." This includes taking advantage of the seller's (commercial) product distribution system in order to maintain absolutely minimum stock levels.

The commercial distribution system begins with inventory management and stocking levels and ends with packaging and shipping practices. Reliance on a contractor's commercial distribution system can result in lower inventory costs through less product surplus; lower spoilage, pilferage, and waste; and a less complex inventory management system. However, to satisfy defense needs, the Government must balance the advantages of this commercial practice against the capability to satisfy unexpected surge demands associated with conflict situations.

INHIBITORS

The inhibitors to commercial practices identified during this study were:

- * 1. Competition Practices
- * 2. Formality of the Government Contracting Process
- * 3. Contract Clauses
  - A. Government-Unique Clauses
  - B. Multitudinous Clauses
  - C. Flow Down of Contract Terms and Conditions
- * 4. Specification Practices
- * 5. Paperwork Requirements
  - A. Certifications
    1. Commercial Pricing Certification
    2. Lobbying-Byrd Amendment
    3. Truth in Negotiation Act (Cost and Pricing Data)
    4. Socio-Economic Clause Compliance
  - B. Reporting
  - C. Records Retention
- * 6. Data Rights
- 7. Data Deliverables
- * 8. Favored Customer Status
- * 9. Cost-Based Buy Decisions
- 10. Protest System/Process
- *11. Audit Rights
- *12. Quality Assurance, Quality Control, and Inspections
- *13. Warranties
- 14. Delays in Prompt Payment
- 15. Terminations
- *16. Propensity for New Development versus Non-Developmental Items
- 17. Inadequate Acquisition Training

* Described in this paper.

The sequence of the inhibitors is not intended to imply a rank ordering or relative importance. Inhibitors can generally be considered as belonging to one of the following categories: the inhibitor is the counterpart to an existing Government practice; the inhibitor forbids a commercial practice by the Government; the inhibitor is a Government right or mandatory activity (founded in law) which must either be modified or rescinded in order to adopt the commercial practice; or the inhibitor is a "usual" Government practice which interferes with or complicates the effective adoption of the commercial practice. How an inhibitor inhibits a commercial practice is discussed in the guidebook. It contains the descriptions of how a commercial practice is specifically "discouraged" from being adopted by a specific inhibitor.

1. Competition Practices

Both the Government and commercial firms use competition, but their practices of it differ, especially regarding mandatory competition. The differences are founded in the basic nature of their roles in society and in the marketplace. For example, everyone has the right to sell to the Government, and there are numerous laws and regulations to ensure equal opportunity and fairness in the process. Absent justification to the contrary, Government buyers must use "full and open" competition with inevitable, sometimes frivolous, protests by losing offerors. Good judgment and common sense are not relevant in this environment, forcing the Government acquisition process to rely on detailed specifications to protect itself from protests. On the buying side of the relationship, everyone except the Government has the right to buy from anyone. There is no corresponding right for the Government. (7)

Although some Government practices are intended to increase competition by ensuring fairness and equal opportunity, they can also act as inhibitors to otherwise "good" commercial practices, e.g., those associated with establishing and maintaining good supplier relationships, cooperative relationships, long-term relationships, volume purchase agreements, and the use of criteria such as past performance/experience in placing orders and in determining the value of warranties. One result is that DOD is perceived as having little loyalty to suppliers and little interest in their long-run stability and strength.

Since the Government must almost always use full and open competition, until recently it was difficult to use contract awards as a tool to motivate current contractor performance. Unlike commercial firms, the Government could not, for example, promote cooperation from vendors by using informal "control" methods such as placing an increasing portion of its orders with the most cooperative vendors. This resulted in Government contracting persons needing to rely more on formal contractual arrangements than did their commercial counterparts. (See Formality of the Government Contracting Process below.)

The Competition in Contracting Act (CICA) is sometimes cited as a source for inhibiting effective competition. However, there is no unanimity or consensus on this point. Some contractor spokespersons, especially those from smaller companies, quickly point out they do not object to CICA and do not want to see changes to it. Other spokespersons view CICA as an impediment and advocate recision or major changes. However, both groups voice complaints about the paperwork associated with CICA and how it's implemented and administered. (See Paperwork Requirements below.)

2. Formality of the Government Contracting Process

When the Government acquires an item from a commercial supplier, the contract developed is usually enormously detailed and complex compared with the usual commercial practice. Government buyers attempt to protect the Government from almost every contingency through the incorporation of voluminous contract clauses. They are intended to insure that the Government receives a quality product at a fair price but are often inconsistent with standard commercial practices and the UCC. The added cost to the commercial supplier for complying with these clauses is passed on to the Government which pays more than a commercial company for the same or similar product.

The Government relies on formal, well-defined contracting mechanisms to realize satisfactory contract performance instead of informal commercial practices such as withholding future business from uncooperative vendors. The resulting longer, more complex Government contract clauses encourages more formal contracts, literal contract enforcement, and a "work to the rule" attitude on the part of the seller. They also promote use of objective decision criteria for quality, testing, and acceptance standards and a relatively severe attitude toward enforcement. Together these practices tend to promote adversarial relationships instead of cooperation and teamwork.

These attitudes are also evident in resolving post-award contract issues. In the commercial sector firms usually try to avoid litigation and resolve issues on the basis of fairness as opposed to the "letter of the law." In contrast, DOD is more likely to pursue legal remedies than are commercial firms. The additional "emotional" burden associated with these non-commercial-type contractual arrangements often not only inhibits vendors from selling to the Government, but discourages adoption of commercial practices as well. The commercial practices of long-term commitments and relationships are also affected by this inhibitor. (Also see the Contract Clauses inhibitor below.)

3. Contract Clauses

Some of the types and uses of contract clauses invoked in Government contracts differ from commercial practices and the use of the UCC. Taken together these not only represent a significant impediment to commercial vendors selling their products to the Government, but make it equally difficult for the Government to be more "commercial-like."

A. Government-Unique Clauses

The following types of **Government-unique** clauses were identified as having significant potential impact as inhibitors. (8:8)

a. Ethics
b. National Security
c. Testing and quality assurance
d. Audit and cost
e. Letter contracts
f. Availability of funds
g. Bid bonds
h. Government property or sources/work on Government installations
i. Subcontracts
j. Pre- and post-award disputes
k. Miscellaneous

The following types of clauses were identified as inhibitors since they have the greatest **differences in content** with their counterparts in the commercial sector. (8:10)

a. Price and payment terms
b. Inspection, acceptance, and return of goods
c. Warranties
d. Limitation of liability
e. Taxes
f. Software and data rights
g. Termination

B. Multitudinous Clauses

The flow down of mandatory contract clauses, whereby each level in the procurement/contracting hierarchy adds required contract clauses to a procurement action (e.g., FAR, DFAR, and Air Force FAR Supplement), is a significant impediment, especially to the small supplier who has neither the staff nor the time to customize contracts for each procurement action. Another manifestation of too many clauses is that Government contracting people, with so many clauses to use, often invoke inappropriate clauses for a particular procurement action.

The commercial practice would be for a company to have one standard contract or a limited few standard contracts regardless of customer. According to one spokesperson, there are only 15 contract clauses required by statute or executive order with approximately 400 mandatory FAR clauses and 200 DFAR clauses, but 11,000 mandatory clauses below the DFAR. (Also see 9:15.) Roughly only a half of the FAR clauses had a counterpart in commercial practice. The problem of multiple, conflicting contract clauses has prompted recommendations that there be a single clause or at most a few alternate clauses in place of the current numerous clauses.

C. Flow Down of Contract Terms and Conditions

In some instances, prime contractors are required by either law or regulation to flow down certain terms and conditions to subcontractors and suppliers. In other cases Government terms and conditions will be flowed down in order to ensure complete compliance with prime contractual requirements. In either case, compliance may be virtually impossible when sourcing decisions have already been made.

Usually, prior to a Government order or solicitation for a commercial item, sourcing decisions have been made, and in many cases procurement is already underway using standard commercial arrangements to satisfy long-projected sales requirements. The contractor has no flexibility to manufacture or procure the commercial item in accordance with Government-unique terms and conditions that are imposed on a prime contractor and flowed down to a subcontractor.

Even when flow down is possible, it may not be practical due to the disruption imposed on commercial production activities by the additional administrative burden of Government-unique requirements. The increased product and administrative costs would jeopardize the catalog or market price of the firm's commercial items, which are based on standard commercial practices and commercial delivery flow times. Government flow down requirements inhibit adoption of standard commercial practices and their attendant potential cost and schedule benefits. (10:344)

4. Specification Practices (Re: FAR Part 10)

The Government often imposes detailed process specifications on how an item should be developed. If a supplier wants to sell its product to the Government, it either requests a waiver from the process specification or "re-creates" its existing product according to Government specification requirements. This new product is then sold to the Government, usually at a higher price than the original commercial version.

Listing process (how-to-do-it) type specifications in the DOD Index of Specifications and Standards (DODISS) encourages their use by DOD buyers, but discourages vendors from selling to the DOD, since their commercially acceptable products were not produced in accordance with the approved DOD process. Commercial suppliers produce products in response to the perceived needs of the marketplace, i.e., the process followed has evolved naturally, honed by the competitive pressures of the marketplace rather than by artificial mandate. Commercial buyers as much as possible limit themselves to specifying "what" is to be supplied, not how to produce the "what."

The use of process specifications should not be confused with the use of product type specifications, which is a normal commercial practice. Many companies have very stringent product specifications that vendors must comply with, often more stringent than DOD specifications. But, as a general rule, buyers do not instruct their vendors on how to produce an item, i.e., they do not use process type specifications.

Government documentation requirements are much greater than in commercial practice. Usually the Government requires ownership of all technical data associated with a product. The Government does not wish to be dependent on the original manufacturer for replacement of the product and acquires the technical data that would enable a competitive reprocurement. In addition to the "normal" vendor-supplied manuals, the Government usually requires a detailed drawing package that would enable reprocurement of the product from another supplier. If software is involved, documents detailing the development methods, source code, and data dictionary are required. If repairs are to be made at the piece-part level, a more detailed maintenance manual will be required. These practices often result in documentation costs becoming a significant portion of the total overall acquisition cost of the program.

5. Paperwork Requirements

The Government for many varied reasons requires more paperwork in conducting its operations than the commercial sector. Prominent examples are requirements for certifications, reporting, and record keeping. Taken together they represent a significant impediment to commercial practices, as well as barriers to vendors who might otherwise be suppliers to the Government.

A. Certifications

This inhibitor usually stems from legislated requirements for contractors doing business with the Government to provide proof of compliance with various laws. The required data is evidence/proof that the contractor is ethical and honest, e.g., is providing the DOD fair value at a fair price or is not bribing Government officials. If the contractor processes a certification improperly, the Government can impose

criminal, contractual, or other liability, causing some contractor spokespersons to recommend a "limitation of liability" clause for such cases.

In other situations, the data are used to justify equality between consideration given and received in the contractual arrangement. An example of this is the requirement to provide cost and pricing data for commercial products. (See FAR Subpart 15.8.) There is no counterpart practice in the commercial marketplace, which relies instead on free market competitive pressures to set a fair price.

An important point to note with this inhibitor is that any certification requirement will add cost to an acquisition since it necessitates special handing and record keeping and is not a normal commercial practice. Four of the most often complained-about certifications are the following:

1. Commercial Pricing Certification

Commercial vendors are required to provide evidence of their product's commerciality in order to benefit from statutes encouraging vendors to sell commercial products to the Government. These reporting requirements are especially a burden to small firms without staffs to deal with the paperwork. They may also be a hinderance to products newly introduced in the marketplace that are without sufficient sales volume to qualify as "commercial" but that may be the most desirable as the latest state-of-the-art. Also affected are products nearing the end of their product life whose sales volume is too low but whose purchase may be necessary to maintain an existing system.

2. Lobbying-Byrd Amendment

The Byrd amendment to the 1990 Interior Department Appropriations Act forbids influencing or attempting to influence any person involved with a contract, etc. in excess of $100,000. Contractors must certify that no public dollars were (are) used to lobby Government and must disclose where private funds are used to lobby. (11)

3. Truth in Negotiation Act (Cost and Pricing Data)

The concept of submitting cost and pricing data, as required by the Truth in Negotiation Act, is unknown in the commercial marketplace. Because cost and pricing data are competition sensitive, commercial firms do not provide it to customers. Many firms forgo Government business rather than submit such data. Alternatively, commercial price fairness is determined by the marketplace through competitive pressures and the law of supply and demand, not on the basis of data deliveries. In addition, the specter of false claims liability is a significant disincentive to contractors considering whether to do business with the Government. The record keeping required to refute such a claim is bothersome and often outweighs incentives to sell to the Government. (12)

4. Socio-Economic Clause Compliance

There are numerous clauses that implement various public socio-economic policies, e.g., environment, small business, and hiring, through restrictions on the contractor's business operations and performance of the contract. Most contractor representatives do not take issue with these clauses per se, but point out that such requirements impose a heavy paperwork burden and are not usually

a consideration in doing business in the non-Government sector.

B. Reporting

Reporting requirements are similar to certification requirements, with many Government reporting requirements acting as barriers to it becoming more commercial-like. One of many examples is the Conflicts of Interest in Defense Procurement Act, which requires annual reporting concerning compensation provided to certain former DOD employees.

C. Records Retention

As part of the paperwork burden associated with defense and Government contracting, records of data and submitted reports need to be maintained and accounted-for for years.

6. Data Rights (Re: FAR Subpart 27.4)

One of the biggest concerns of vendors selling to the Government is Government actions that result in the release of technical data to competitors without reimbursement. Although this may not be an inhibitor to the Government adopting commercial practices, it is a Government practice that is non-commercial-like and needs to be remedied if the Government is to become more commercial-like in its acquisition practices. For example, relaxation of this requirement would encourage more vendors to compete for Government business and perhaps result in better value for dollars expended. Today, vendors must decide whether to forgo bidding on a Government contract, work with the contracting office to remove the requirement, or risk release of competition-sensitive data which could jeopardize their survivability. One possible fix to the problem is a recommendation that FAR Subpart 27.4 be amended to assure that the Government obtains only limited or restricted rights in technical data for commercial products.

8. Favored Customer Status

The Government often requires a "most favored customer" price although it does not act like a most favored customer, demanding terms and conditions unlike those offered with the "most favored customer" price. For example, preferred customer rates are a prerequisite for a supplier to be listed on the GSA Multiple Award Schedule even though the Government will not guarantee a minimum sales volume. This unfair requirement keeps qualified suppliers from wanting to do business with the Government.

9. Cost-Based Buy Decisions

The Government conducts business on a fundamentally different basis than commercial firms. The Government is first concerned with the cost of an item and then its price, usually as a function of cost. The Government not only uses cost-type contracts, but its price contracts are also derived from a cost basis. In the commercial sector the buying decision is focused on price. Negotiations are done on the basis of price, not cost. The seller, not the buyer, has access to an item's cost data. The Government's orientation toward cost not only inhibits vendors from selling to the Government, but also inhibits it from becoming more commercial-like in its practices.

Often the Government's purchase decision is made without regard for other components

of value, such as ease of use, maintenance, and frequency of repair. The best value item may not have the lowest initial purchase price, but over its life cycle its cost will either be sufficiently lower or its useful life will be significantly longer. The Government may be able to reduce overall acquisition costs if the barriers to buying best value were removed. (See the discussion on "best value".)

11. Audit Rights (includes Government visits and Government oversight in general)

One of the most frequently mentioned statutory impediments to adopting commercial practices was the Government's right to conduct audits of contractor's internal records at the Government's discretion. No commercial firm selling to commercial customers permits customers to audit its internal records. This is an area in which the nature and rights of the Government are barriers to it becoming more commercial-like in its practices. The Government's rights, duties, and obligations are different from commercial firms, and the need to be effective in the management and operation of the Government must be reconciled to them, i.e., the Government will not be able to adopt all commercial practices *carte blanche*.

12. Quality Assurance, Quality Control, and Inspections (Re: FAR Part 46)

Not only are Government quality requirements themselves inhibitors to commercial practices, but so are the procedures and forms used in their implementation. Contractors would prefer that the Government rely on the contractor's inspection and quality assurance programs rather than specify its own requirements for such programs. Contractors would also prefer that the Government behave like their commercial customers and utilize their existing commercial shipping and invoicing systems. In-process inspection, which is the usual practice on many Government contracts, is not a usual practice in the commercial sector, i.e., commercial firms do not conduct in-process inspections of their supplier(s) during production. Inspections are done, if at all, during/at acceptance.

The DD Form 250, Material Inspection and Receiving Report, is a multi-use form for packing, receiving, shipping, quality, and inspection. It is an impediment in at least two important ways. First, there are unnecessary delays in executing the quality and inspections portions, i.e., getting the required signatures. Second, the invoicing and shipping portions are usually incompatible with commercial computerized systems.

13. Warranties

Warranties may be a factor in determining best value. The inhibitors to commercial-like warranty practices are the FAR/DFAR warranty clauses. If the FAR warranty clauses were revised to be more in line with what commercial companies usually offer, DOD practice would be more commercial-like and help increase the number of suppliers willing to do business with the Government. Different warranties for the same product for each customer are too costly for a seller to administer. DOD warranty practices inhibit adoption of commercial warranty practices.

16. Propensity for New Development Versus Non-Developmental Items (Re: FAR Part 11)

An example of both a cultural-based and a regulatory-based inhibitor is DOD's propensity to favor (issue) guidance for new development efforts while providing relatively little guidance for NDI. There is sound justification for public guidance on developing defense-unique products, but its sheer volume has overshadowed the need for NDI acquisition guidance. There is relatively little guidance to DOD buyers on differentiating between situations that require DOD-unique items instead of existing products. Often the more detailed and costly requirements and safeguards associated with DOD-unique items have been imposed by default on existing products. This overburdens NDI acquisition, discourages vendors, and inhibits adoption of commercial practices.

CONCLUSIONS

There were no major revelations in the commercial practices and inhibitors identified during the study. Individual practices are generally known in the acquisition community, with isolated instances of them being practiced in various forms and to differing degrees. However, there is no uniform nor widespread adoption and use of commercial practices in DOD due in part to no readily available reference source of information and a lack of publicity about them and their inhibitors.

Publication of a guidebook will provide a readily accessible collection of information on commercial practices and their inhibitors applicable to DOD acquisition that can be used and updated through experience. The guidebook can be a catalyst for expanding the identification of commercial practices and promoting broader acceptance and adoption.

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TOTAL QUALITY MANAGEMENT (TQM)

and

TOTAL QUALITY CONTROL (TQC)

A NEW PHILOSOPHY IN GOVERNMENT QUALITY ASSURANCE

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ABSTRACT

Over the period of the past 30 years, an operational philosophy emerged that determined how the government ensured the products and services it contracted for were what it received. Essentially, the government inspector, known as the Quality Assurance Representative (QAR), would inspect to the letter of the contract, and any deviation was formally recorded. The purpose of inspection was to indicate where correction was necessary. It was then up to the contractor to develop solutions to any problems, without any assistance from the QAR or others in the government acquisition community. The government's responsibility was defined as simply making sure it did not accept bad product. Everything else was left up to the contractor.

This basic philosophy is now changing in the Department of Defense (DoD) to one that envisions a very different relationship between the government and contractor. In the future, the on-site QAR will be expected to have a much more interactive role in the process. Indeed, the focus has been shifted from the product itself to the process whereby the product came into being. The QAR, with assistance from other government acquisition personnel, is now encouraged to understand the company's processes, make informal suggestions for improvement, and use various analytical tools to evaluate the processes at work. Inspection becomes only one of the tools in this new method; it is no longer even the preferred method to ensure conformance. Inspection is still accomplished, but with the goal of indicating where improvement is possible or desirable. Similarly, formal notification of deficiencies is a tool now used only as a last resort.

After a brief background review, this paper will describe the new philosophy by comparing past practices to the new ones. Thus, the differences and similarities will become clear very quickly. The early lessons learned in using the new philosophy will then be reviewed, as they provide a guide to others desiring to use it. The previous system was known as the Contractor Quality Assurance Program (CQAP). The new system is known as In-plant Quality Evaluation (IQUE).

BACKGROUND

The basic right of any buyer to get what he paid for is not disputed here, for this has been established for many years. When it comes to government contracts, the Federal Acquisition Regulation is quite clear. Part 46 of the FAR, titled "Quality Assurance", states in its very first sentence that it is the government's intention "... to ensure that supplies and services acquired under Government contract

conform to the contract's quality and quantity requirements."[1] There are ample words in the various contract clauses to put contractors on notice that the government expects to receive what it contracted for. What is being discussed here is the methodology used for ensuring that results are as expected. CQAP has been the operating mode for many years, and has been codified in a joint manual that in the Defense Logistics Agency (DLA) is designated DLAM 8200.1. An insight into the basic philosophy of CQAP can be inferred from the Foreword, which reads, in part:

"... the manual addresses itself to the policies, procedures, and actions that are required to be implemented at the site ...

... the efforts of all PQA personnel ... are directed toward the single purpose of assuring that the supplies or services are in complete compliance with the terms of the contract ..." [2] (underlining added)

It is obvious that the 'letter of the contract' was the primary focus of CQAP, with little concern for the workings of contractor's systems.

In early 1987, Brigadier General Pepe, HQ DLA Quality Assurance Director, initiated a major review of the practices in the field, with the intention of improving customer satisfaction.[3] This wide ranging review looked at all aspects of the QA function. Of the many problems given as reason for concern, three are cited:

1. Audits of several DLA depots showed that 7.5% of the parts in stock at the depots that had been inspected by government QARs at the contractor's plant were defective.

2. Work load in the government QA community continued to increase with no increase in personnel. The resulting need for flexibility or creative solutions was not permitted under the existing rules.

3. The military departments continued to complain that all that DLA QARs did was "check paper." This implied basic dissatisfaction with the level of service received. The DLA QA community was perceived as not really committed to the services' needs - a quality product delivered on time and at reasonable cost.

Over the next three years the concept of IQUE developed. In 1989 several companies participated in testing the program. In May 1990, DLA-wide implementation was approved. Since all DoD contract administration services (CAS) functions, including quality assurance, have been consolidated under DLA's new Defense Contract Management Command (DCMC), IQUE will impact virtually every defense contract and contractor. DCMC is planning on having IQUE in place at all defense contractors by mid-1991.[4]

Though the basic concepts of IQUE are consistent with the Total Quality Management (TQM) philosophy, it appears that IQUE did not arise out of the formal

DoD TQM program launched in the summer of 1988.[5] By that time, the DLA QA community had already been working on what became IQUE for well over a year. Of course, the developers of IQUE relied heavily on the thoughts of such people as Deming, Juran, Shewhart, Ishikawa, Taguchi, and Crosby, most of whom are also cited in TQM literature.

Looking to the Foreword for an indication of emphasis, the IQUE manual, DLAM 8200.5, gives an insight to the new philosophy:

> "... the primary objective of IQUE is to ensure acceptance of conforming products. IQUE provides guides for government in-plant QA personnel to consider and tailor to individual contractor facilities ...
>
> ... It focuses on ... a spirit of teamwork to measure and continuously improve processes and resulting product quality ...
>
> ... The goals are to achieve customer satisfaction, improved product quality, and a reduction in the costs of items and ownership."[6] (underlining added)

One can see that the central objective of quality assurance has not changed. A product conforming to the contract is still primary. The underlined words reveal the underlying concept of IQUE. It is success through understanding the processes involved, and teamwork between the contracting parties to meet all the customer's needs that motivates IQUE. These concepts are foreign to CQAP.

OLD AND NEW COMPARED AND CONTRASTED

The two systems can be compared and contrasted by grouping their main characteristics into three areas: focus, the nature of instructions, and the principal actors.

Focus

Key concepts relating to the focus of the two philosophies are shown in Figure 1.

Focus

CQAP
- Conformance to Specs
- Defect Detection
- End Item Inspection
- QAR is Policeman
- Quality seen as Static

IQUE
- Customer Expectations
- Defect Prevention
- Process Verification
- QAR is Team Member
- Quality seen as Continuously Improving

Fig. 1

CQAP was motivated by the goal of strict conformance to specifications. In order to assure this, inspections became the key to prevent defects in accepted products. These inspections focused on the measurable features of the products and checking the procedures used by the company to make the product, to see whether they conformed to the standards set down in the contract. Defect detection, primarily through inspection of the deliverable end item, was the norm. This naturally result-

ed in a "policeman mentality" where rigid checklists and sampling plans were used to determine which characteristics would be checked, and how often. This attitude prevailed in contractor QA departments as well as the government QA community.[7]

An example of this is the Acceptable Quality Level (AQL) charts that determined how much non-conforming (i.e. defective) product was acceptable. Depending on the product and application, from one to four percent of a production lot could be presented to the government and fail testing, yet the entire lot would be deemed acceptable.[8] This "plan to fail" was integral to both the MIL-I-45208 and MIL-Q-9858 standards that were supposed to prevent any nonconforming product from being presented to the government for acceptance.

IQUE, on the other hand, focuses on the processes that contribute to the meeting of customer requirements. Any defects in delivered products or services are considered as evidence that the whole system of interrelated processes has failed. Therefore, defect prevention through controlled processes is the key. The focus is on verifying that the process is robust enough to consistently produce product that meets all of the requirements and expectations of the customer. The concept of a robust system is that a process is in control only if all output is well within the specs for that system, and the variations are small. Any product that arrives at any check point in the process and is found to be out-of-spec is an indication that the system is out of control.[9]

Everyone who has a stake in the outcome is expected to contribute to improving the process. This includes the government inspector, as well as other government contract administration specialties. Rather than be a policeman, the QAR and the supporting CAS office are now team members with the contractor. Similarly, the contractor's QA personnel are expected to take off their black hats and creatively work for improvements. This involvement should start at the design and development stages, continue to production planning and execution, and carry on through post-delivery service to the customer.[10]

Finally, the focus of the new system can be defined as a commitment to continuous improvement, where the quality of the total product is being closely measured so that it can be incrementally improved. The CQAP system defined quality simply as conformance to a static set of specifications and requirements. CQAP's goal was to give the customer what he paid for, and that's all. Unfortunately, the system proved unable to deliver even that.

Nature of Instructions

Figure 2 shows the main differences in how instructions are given in the two systems.

CQAP, as defined by the DLAM 8200.1 and the services' corresponding manuals, is very rigid. This is evident in the portions of the Foreword quoted above, where "instructions" are given. Further, local supplementation was not permitted. This could be done only at the Depart-

Nature of Instructions

CQAP
- Rigid Requirements
- Highly Controlled
- Specific Rules, Tables
- Mandatory Inspections
- Contractual Remedies

IQUE
- Guidelines
- Less Control of Methods
- Flexibility Encouraged
- Process Verified
- Broad Range of Solutions

Fig. 2

ment or Agency level. There are very specific rules throughout the CQAP system, and many mandatory tables that result in a cookbook approach to quality assurance. The in-plant QAR was not given the authority to deviate from these rules. Inspections occurred at the time and frequency determined by the tables, and not by what made sense. For example, calibration equipment had to be checked every 180 days, whether it had been used since the last check or not.

This approach was not altogether wrong. Given the fact that hundreds of DoD customers were trying to get predictably good products from thousands of suppliers, setting up a clearly defined and unambiguous QA system made sense. However, all too frequently, when a seemingly minor problem arose, the CQAP system forced the contractor to seek contractual relief through waivers or deviations. This caused delays and unnecessary expense on both sides and did little to address systematic issues.[11]

The emphasis of IQUE, however, is to give only "guidelines," stating only principles of what to do, but not give the details of how to do it. The details are, in the main, left up to the local QAR and supporting staff. Indeed, supplementation of the new DLAM 8200.5 is prohibited, except at the plant level! Intermediate headquarters may not add their own interpretations or more rules. This gives the people most interested in problem solving, the customer and QAR along with the contractor, the power to make reasonable decisions within broader guidelines. Mandatory end item inspections now give way to process or product audits, where the goal is to verify that the process is in control.

The verification that the processes are in control is called process proofing. This involves examining each stage to assess how effectively and accurately requirements are input into the processes, and how well the process incorporates these into the outcomes. Any activity within the company may come under scrutiny, for it may have a significant impact on the product even though it may be very indirect. This proofing process is not the domain of just the government QAR, but must be a joint endeavor with the company if it is to succeed.[12]

To accomplish the above, the QAR must use many new tools that, though not prohibited before, were simply not used. These new tools include such things as flow charting, statistical process control, Pareto analysis, control charts, and oth-

ers.[13] IQUE thus expects the QAR to think creatively, select the appropriate techniques and tools, and then develop solutions that make sense at the plant concerned.

Among the tools now available for use, flow charting is a most important starting place for understanding just how a company operates. The flow of information is analyzed and the possible results at each decision point is determined, so that all possible branches and their impact may be known. After flow charting a process, many companies are surprised to find that things do not happen the way managers think they do and that there are many more holes in control systems than they ever imagined. One company found that in some instances a petty cash fund intended for use on R&D work was regularly used to purchase unauthorized repairs on production hardware. The resulting recall of the product was very expensive![14] But by using this tool, the company uncovered a process in the factory that was hidden from view, a process that could have created an even greater disaster. This is often referred to as the "hidden factory," and flow charting is uniquely able to uncover its existence and extent.

Once the reality of the process is revealed, the problem becomes controlling it. Then predictably good results may be obtainable. Statistical process control is frequently useful in this effort. Data is collected that shows variations in key product characteristics, and then system adjustments are made until the deviation around the target performance level is very small. If deviations are very small, the likelihood of product failure is greatly reduced. A famous case in the automotive industry illustrates this point. A component was made by two suppliers, both which delivered a good product. However, customer complaints were higher for the components from one of the suppliers. Analysis showed that the better supplier's products had much smaller deviations around the target specifications than the other supplier. Both were "in spec," but one had better control, and this showed once the product was put into service.[15]

<u>Principal Actors</u>

Figure 3 highlights the differences in the roles played by those involved in the process.

Principal Actors

Government	Contractor
Under CQAP:	
QAR	QC Dept.
Under IQUE:	
QAR	
QA Staff	QA Staff
Engineering	Engineering
Production	Production
Contracts	Contracts

Fig. 3

Under the CQAP philosophy, assuring a quality product was the job of the quality experts. Contractors sequestered these experts in the Quality Control or Quality Assurance department. The government followed suit: the QAR and the Quality Assurance Division were virtually the only

contacts the contractor had on a day to day basis with the government. Thus, communication was narrowly channeled and controlled by both sides. The government QAR kept busy telling the contractor what was wrong through formal communication. These Quality Deficiency Reports (QDRs) were not to suggest solutions, because this would be "doing the contractor's job." The contractor's QC department then had the sole responsibility within the company to avoid QDRs, and answer the ones it could not avoid.

The corrective actions presented by the contractors in response to the QDRs invariably addressed the immediate problem. Both sides felt that the range of solutions was very narrow, because of the nature of the governing regulations. Rarely was there time or interest in broader systematic solutions.[16] The entire focus was on the urgent need to keep production flowing, and short, simple replies worked best.

With the advent of IQUE, however, the number of actors has increased. The government is now expecting to participate in the process of improving the various processes in the company that are not yielding good results. This means that the government QA technical staff, and many other functional staff members in the contract administration office, will now be involved early on. For the contractor, the same is true. All departments that have an impact on the product will be participating in direct communication with the government representatives, and other departments within the company. With open communication, it is expected that better solutions will be achieved more quickly, and at less total cost to all concerned. With other functional areas involved, integrated solutions tend to be considered, and systematic problems may be revealed much earlier than before.

Results have been consistent with this concept. During the test program at one contractor a systematic problem was discovered by a QAR as a direct result of applying the IQUE philosophy. In a generic printed circuit board build process, a chronic "wrong parts" problem was identified, though it was not apparent when looking only at an individual program's boards. The error rate quickly dropped to one tenth of the previous level, once the problem became apparent.[17] The problem was there all the time, but until someone analyzed the process, rather than the individual outputs, the problem was hidden.

LESSONS LEARNED

The test program mentioned above involved contractors of varying sizes and product lines, and included 25 major companies and 115 medium and small companies. Based on interviews with management within DLA and the contractors, and the author's own experiences, it is becoming apparent that the following points are important lessons learned during the test program. They are listed in Figure 4. Of course, more will be learned as IOUE is adopted by thousands of contractors and government offices over the next few years.

There is no doubt that IQUE is a radical

Lessons Learned

Radical Departure from Past
- Management Support Vital
- Consistent Goals
- Open Communication

Cookbook Hard to Put Aside
- Refuge for QAR
- Known Standard to Company

Flow Charting Key 1st Step
- Processes Misunderstood
- Hidden Factory

New Skills Needed
- Communication
- Computer
- Statistics
- Abstract Thinking

Internal Cultural Barriers
- Between Functions
- Professional Attitude

Fig. 4

departure from the past, for the reasons stated above. Therefore, it is absolutely crucial that management support be genuine, and at all levels. Cultural changes do not happen easily, but they can be brought about with the right support. Related to this is the fact that the government officials involved and company management must have consistent goals. One of the clearest lessons from the test program is that without sincere management commitment and active support, IQUE will fail.[18] Hidden agendas or diverse priorities cause counterproductive friction in an environment that must have open communication. Many people fear an attitude of openness with those who once were considered mortal enemies. This is a basic problem that only management can resolve or alleviate.

The cookbook approach is hard to put aside, since it is the only way most QA personnel on both sides ever knew. The DLAM was a comfortable refuge for the QAR, and a rather predictable (and unmovable) standard to meet for the contractor.[19] The accusation of being only "paper checkers" may have arisen from bad experiences with this approach.

The skills needed by those in the QA community are now quite different from before. Communication skills, computer literacy, basic statistics and math skills. and an ability for abstract thinking are now essential. This is true not only for management, but the front line QA personnel. Previously, none of these were *considered primary* job qualifications, particularly among government QARs. For those without these skills, IQUE can present a threat to their self-image and sense of professionalism. DCMC is addressing this by giving two weeks of training covering IQUE and statistical methods to all QA specialists.[20] Training programs will help alleviate the technical shortcomings and some of the self-perception issues, but some people will still have great difficulty making an effective transition.

On the other hand, IQUE can increase self-image because the methods now favored can instill a sense of job ownership in employees. The front line QA personnel are encouraged to think and be creative as they resolve problems in the processes. Already there have been sur-

prises as to who can make the change, and which companies and individuals can't.[21] Some hard-line old-liners have embraced IQUE rather quickly, while others remain reluctant to change.

Internal cultural barriers can cause problems, too. At one contractor's facility, control charts were posted by the various machines, and the operators instructed to make adjustments when the data started drifting towards an out-of-spec condition. The assumption was that pride of ownership would motivate the operators. However, many operators felt that it was QA's job to inspect, and many QA inspectors saw their jobs threatened. The new procedure appeared doomed almost from the day it hit the shop floor. Fortunately, management was able to effect a cultural change, and now both the operators and QA inspectors see the benefit of the charts.[22] The operators can control their destiny, so to speak, and the QA personnel are engaged in looking at the system, rather than individual job lots.

Similarly, the QAR is now encouraged to have a sense of ownership in what is being produced, and how it got produced in the first place. An attitude of professional detachment was the norm in the past, because the company's processes were not the QARs primary concern. In a real sense, CQAP was activity oriented, focusing on static requirements and required inspections. IQUE, on the other hand, puts the focus on results and value added activities. The QAR is now permitted to decide what is most important, and therefore can feel more job ownership in the process. Professional involvement is now the preferred attitude. Now the process is primary, and everyone is expected to contribute to ensuring that the processes are in control and invariably producing a product that meets customer expectations.

SUMMARY & CONCLUSIONS

Because of dissatisfaction with the status quo, DCMC has embarked on a journey that will improve the usefulness of the goods and services needed for the military. The new philosophy is focused on the processes that go into contract performance, because if the processes are working right, the outputs will be as expected. If the processes are not in control, or are poorly understood, then the output will be predictable only in that it will be unpredictable.

This fundamental change of philosophy will not be easy. For some companies and individuals it may never yield the expected results, because the capacity for or the willingness to change is simply not there. Yet, for those who successfully make the change to IQUE, the results can only be beneficial, since uncertainty will be reduced or eliminated. The natural result will be efficiency of the whole and a minimized resource input for the desired products and services.

ENDNOTES

[1]FAR, Part 46, Quality Assurance, April 1984.

[2]DLA Manual 8200.1, August 1976.

[3]Martin, Charles, QA Division Chief, DCMAO El Segundo, interviews by

author, Spring and Summer 1990.

[4]See Capt. Richard Monash, USN, "HQ DLA's Perspective on IQUE," briefing charts and script, HQ DLA QA Directorate, Fall 1990.

[5]Total Quality Management Master Plan, Department of Defense, August 1988.

[6]DLA Manual 8200.5, September 1990.

[7]Walker, Edward D. "IQUE - DLA Joins the TQM Revolution," National Defense May/June 1990.

[8]Course materials from "CQAP Primer for Managers," DCASR Los Angeles, Fall 1989.

[9]DLA IQUE Student Workbook, Course S85, Jan 1990.

[10]Richard DiPiazza, "Changing Role of Quality," briefing materials, DCMAO El Segundo, Spring 1990.

[11]Robinson, Ava, IQUE Project Officer, DCMAO El Segundo, interviews by author, Spring 1990.

[12]Monash, Richard, HQ DLA QA Directorate, interviewed by author, Fall 1990.

[13]DLA IQUE Workshop Lesson Guide, March 1990.

[14]By agreement, the identity of the company will not be released.

[15]DLA IQUE Workshop Lesson Guide, March 1990.

[16]DiPiazza, ibid.

[17]Walker, ibid.

[18]IQUE Pilot Program End of Test Report Jun - Dec 89 from the Defense Plant Representative Office, Rockwell Missile Systems Division, Duluth Georgia, April 1990.

[19]Monash briefing previously cited.

[20]Ibid.

[21]Woelki, George, Director of QA, AiResearch, Torrance, interviews by author, Fall 1990.

[22]Ibid.

APPLICATION OF TOTAL QUALITY MANAGEMENT (TQM)

TO ACQUISITION OF CONSTRUCTION SERVICES

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ABSTRACT

The acquisition of design and construction services is an area in which current performance leaves much to be desired. The industry is beset with problems which range from the inability of owners to properly define their objectives, to the failure of designers to properly illustrate what it is that is to be constructed, and to contractors, frequently providing an end product which does not meet owner expectations.

A promising approach to solving these problems and achieving quality is Total Quality Management (TQM) which is rapidly being adopted in the manufacturing industry. TQM goes well beyond the traditional limits of Quality Assurance (QA) and Quality Control (QC). It is an operational philosophy which focuses on <u>customer satisfaction</u> and <u>continuous improvement</u>.

Stemming from the principles of Drs. W. Edwards Deming and J.M. Juran, common elements of TQM programs include focus on customer satisfaction, strong management commitment and leadership, training and motivation programs for all employees, teamwork approach to problem identification and resolution, emphasis on prevention rather than correction, supplier involvement and improvement, improved communication, to include customer, supplier and employee feedback, recognition for achievement, and continuous improvement.

There is evidence to show that TQM is beginning to be adopted by some segments within the construction industry, such as industrial owners, their designers and contractors. In addition, the Associated General Contractors of America (AGC) has embarked on an awareness and education program among its members.

Owners, both public and private, should take a leadership role in helping move the industry toward full implementation. Designers, contractors and suppliers should not wait on owner initiatives. They should move to adopt TQM within their organizations.

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INTRODUCTION

The acquisition of design and construction services is an area in which current performance leaves much to be desired. The industry is beset with problems which range from the inability of owners to properly define their objectives, to the failure of designers to properly illustrate what it is that is to be constructed, and to contractors, frequently providing an end product which does not meet owner expectations.

In a recent workshop addressing the design and construction acquisition process, a group of owners, designers and contractors developed a list of fifteen problems they considered to be serious or very serious.(1, pp. 13-22) Key among these were ...

- Lack of teamwork
- Lack of communication
- Inadequate planning and scheduling
- Inadequate training
- Poor quality of materials, installed equipment and workmanship
- Poorly defined work and scope
- Inadequate project leadership

The serious nature of these problem areas indicate that the process of procuring design and construction services could stand substantial improvement.

Traditional approaches to improving quality have focused on obtaining quality by adding more volume to specifications, and by adding additional levels of inspection. These approaches have only added costs to the projects and confused the issue of accountability. The same problems continue to exist.

There is a solution. An approach to achieving quality which has proven to be successful and which is rapidly being adopted throughout the manufacturing industry is Total Quality Management (TQM). TQM goes well beyond the traditional limits of Quality Assurance (QA) and Quality Control (QC). It is an operational philosophy which focuses on customer satisfaction and continuous improvement.

TQM may be called by other names, such as Quality Management, Quality Improvement, etc. However, most of these programs contain the same basic elements. They are based on the principles of Drs. W. Edwards Deming and Joseph M. Juran. The adoption and refinement of these same principles by Japan, starting in the 1950's, has helped propel them to their current position of preeminence in the world economy.

The principles of TQM also form the basis for the recent successes in quality improvement demonstrated by the winners of the prestigious U.S. national award for Quality--the Malcolm Baldridge Award. Such companies as Xerox, Motorola,

Cadillac, 3M, and Federal Express, have adopted the basics of TQM as an integral part of their company culture.

They have proven that a total commitment to quality improvement through the application of a comprehensive TQM program can do wonders for a company. Improved products and services, happier customers, greater productivity, and increased sales are what has resulted.

And yet, even though there has been dramatic progress in implementing TQM in the manufacturing sector, very little evidence exists to indicate that same focus or success in the building sector of our economy. And, this is especially so in the public sector.

What are we to do? Sit back and let the world pass us by? Or, are we going to become TQM activists and lead the charge for quality improvement in our building industry. It's time to catch up and move ahead.

This paper discusses the quality problems in the building industry, the TQM process, it's potential applicability to the acquisition of design and construction services, and the current focus on TQM by the Associated General Contractors of America (AGC).

PROBLEMS IN THE DESIGN AND CONSTRUCTION ACQUISITION PROCESS

In the late 1970's, the perceived inability of the construction industry to deliver cost effective facilities to owners caused the Business Roundtable to sponsor the "Construction Industry Cost Effectiveness (CICE) Project." Published in 1983, the resultant study outlined major weaknesses in the construction industry, which include (2):

- Poor safety performance accounting for approximately 6-½% of the total cost of all industrial, utility, and commercial construction.

- Improper use of overtime unnecessarily raising the cost of construction.

- Foremen undertrained.

- Workers demotivated, resulting in low productivity, high absenteeism, and high turnover.

- Craftsmen undertrained.

- Owners, contractors and A/E firms giving a cold shoulder to improved technology.

- Modern management systems not being used.

- Too many engineers, separated from field experience, not up to date about how to build what they design, or how to design so structures and equipment can be erected most efficiently.

- Government interference through the promulgation and administration of overlapping, duplicative, and sometimes conflicting regulations at all levels, forming a barrier to increased productivity.

One of the supporting CICE reports, Modern Management Systems, addressed Quality Assurance. The findings in the report include (3):

• The application and benefits of quality assurance/control programs neither fully understood nor effectively utilized in the planning, design and construction phases of many projects.

•Very few companies measuring the cost effectiveness of their quality management programs.

• Owners showing the least interest in implementing formal quality management programs even though they stand to benefit the most from improved quality.

A national conference on "Quality Assurance in the Building Community," held in Dallas, Texas, in July of 1983, echoed many of the same comments.

In May of 1989, the Construction Industry Institute (CII) stated,

> "The U.S. construction industry is ill. Productivity has declined significantly in the past two decades. Delays in construction are common and expensive, and litigation related to design and construction continues to increase." "Research results from a study of nine industrial projects, with individual project costs up to $900 million, show that rework alone represents an average of 12 percent of the total installed costs." (4, p.1)

Then again, in the May, 1990 workshop on TQM held in Des Moines, Iowa, many of the same problems were again identified as prevalent in the industry. These were briefly mentioned in the introduction. The same problems appear to still be with us.

The cost of these problems to all Americans is enormous. Everybody suffers; owners, designers, contractors, subcontractors, suppliers, their managers, their workers, and consumers. Owners do not get what they want; designers and contractors lose potential business and must redo a portion of their work; suppliers lose potential business and may have to replace faulty materials; workers become frustrated and lose motivation and pride in their work; and the consumer must pay the increased cost that results from poor quality. We can no longer afford to remain indifferent to these problems. The time to take action is upon us. TQM offers the potential of a long-range, effective solution.

WHAT IS TOTAL QUALITY MANAGEMENT (TQM)?

There are certain fundamental elements which characterize TQM, and which have their origin in the principles of Dr. Deming. The definition of TQM and the fundamental elements may vary depending on the source. However, a good place to start is the Total Quality Management Plan prepared by the Defense Logistics Agency (DLA), January 1989 (5).

According to DLA,

> "TQM is:
> - A systematic process for improving products and services.
> - A structured, disciplined approach to identifying and

solving problems.
- A participatory work style, conveyed by management actions and commitment, which harnesses the creativity and ideas of all employees.
- Long term
- Supported by Statistical Process Control
- Practiced by each and every employee." (5, p. 2)

Certain elements appear to be common among TQM programs. These include:

- Focus on customer satisfaction, including programs to measure that satisfaction

- Strong management commitment and leadership

- Training and motivation programs for all employees

- Teamwork approach to:

  - identifying problems and causes

  - examining and measuring processes

  - solving problems

- Prevention rather than correction

- Supplier involvement and improvement

- Improved communication, to include customer, supplier and employee feedback systems

- Recognition for achievement

Patience is required, because the process of implementing a TQM system within a company may take several years. Once the system is up and running, efforts must focus on continuing improvement.

The first element of TQM, customer satisfaction, goes beyond "meeting the specifications" or "meeting requirements." It is a philosophy which permeates the organization and transcends the "every man for himself" approach. It becomes the ultimate goal of every employee. Attitudes and operations are oriented toward customer satisfaction. More emphasis is placed on defining the customer's needs and wants, translating these needs and wants into accurate plans and specifications, and then performing construction in such a manner that the customer's expectations are met.

The concept of "customer," when applying TQM, needs to be broadened. Typically we think of the customer as being the person, external to the company, who receives the end product or the service. In TQM, that concept broadens to include anybody that receives a product or a service from another. That means that within our own organization, we have customers. A site superintendent is the "customer" of the purchasing department, the warehouse, the maintenance shop, payroll department, the scheduling department, etc.

To insure that customer expectations are being met, a company must structure an information gathering program that constantly measures the level of customer satisfaction. This program must seek out any possible areas of dissatisfaction, and must feed this information back to the company so that action can be taken to

eliminate the source of any dissatisfaction. This is true for both the external and internal customer. Ishikawa, a leading Japanese authority on quality management, claims that as a first step in quality control (or quality management, if you will) it is imperative to make the customer complain so that you know where you are (6, pp. 82-83). The identification of customer perceptions should be pursued aggressively, since, as he points out, the known complaints probably represent only the tip of the iceberg.

Implementation of a TQM program also requires strong management commitment and leadership. Senior managers need to attend quality schools or seminars and become convinced that TQM is needed for them and their company. Then they must personally lead the way and support the implementation of a TQM program.

A keystone to a successful TQM program is training. Training is necessary because of the requirement for a participative, disciplined, and organized approach, and the requirement for the evaluation of quantitative data. Employees need training in teamwork, inter-personal communication, process improvement, and technical skills related to their particular job. All levels and types of employees, including management, line and staff, need this training. Companies who lead in implementing TQM are investing heavily in training. Motorola, for example, has a goal of five days of training per year per employee (7).

Trained Quality Teams, or Quality Circles, are used to provide for process improvement. These teams usually consist of a representative from each area that might be involved in a process. All levels involved are represented, including management and line personnel, and where appropriate, the customer. Suppose, for example, that a producer of door closers was receiving numerous complaints from customers that the closers were failing after just a few months of use. The manufacturer would then form a team to investigate the problem. The team would probably include representatives from design, manufacturing, and management. The source of the problem would be identified, and solutions developed. Subsequent performance would be measured and evaluated to see if further action should be taken.

Problem identification and solution focus on the **processes** involved. A process might be the vibration of fresh concrete, the fabrication of structural steel, the preparation of a shop drawing, or the way in which a project manager deals with a client and with other members of the team.

Continuous improvement means that every employee in a company is never content with the status quo. They are always looking for ways to improve. This feature distinguishes TQM from many other short-term management fixes. TQM, if properly applied, is not a "here today-gone tomorrow" management fad. This is demonstrated by the long-term success of the program in Japan.

TQM places emphasis on prevention, not correction. Deming says,"Routine 100 per cent inspection is the same thing as planning for defects, acknowledgement that the process cannot make the product correctly, or that the specifications made no sense in the first place...Quality comes not from

inspection, but from improvement of the process." (8, p.22) This does not mean that inspection ceases. Instead, it means that more effort goes into preventing errors and deficiencies. Inspection continues, but its primary function is to provide information that can be used to identify problem areas that must then be studied so that a particular process can be improved. This approach places a positive rather than a negative emphasis on inspection.

The delivery of a finished end product, whether it be a building or an automobile, or a service, whether it be a travel itinerary or a meal in a restaurant, requires the services and products of other suppliers. In building construction, this includes numerous subcontractors and material vendors. Contractors cannot deliver a quality facility to an owner without the active participation of their suppliers in their quality program. Deming goes so far as to recommend that the number of suppliers for a particular service or product be reduced to "one." Whether or not one ascribes to that philosophy, TQM envisions that companies clearly outline their expectations to their suppliers, then help them improve. Suppliers are expected to implement their own quality management programs. If suppliers cannot meet the quality standards of the buyer, then they are dropped as suppliers.

Improved communication is another key ingredient of TQM. This means improved communication between departments within a company, between employees and managers, and between owners, designers, contractors, subcontractors, and suppliers. This increased communication aids in identifying expectations and instances where these expectations are not met. As a part of improved communications, barriers to two way communication within companies must be broken down. All employees should be encouraged to provide recommendations to management, and management must learn to communicate effectively with employees. Training in interpersonal communication and team- building exercises will help this effort.

There should be some form of recognition for achievement. Employees take pride in accomplishment. These accomplishments should be recognized in some manner, whether it be a company newsletter, recognition dinner, certificate, or monetary reward. This recognition fuels the fire and serves as a motivator for continued contributions to process improvement.

TQM has been successfully employed in Japan and in the U.S. manufacturing industry. The recent award of the Deming Prize, a Japanese award for quality progress, to Florida Power and Light, and the Baldridge Award to Federal Express, show that the TQM concept is now being applied by the service industries as well. TQM provides a proven mechanism for improvement. The Construction industry should look to TQM to help it solve it's quality problems.

APPLYING TQM TO CONSTRUCTION

The participants of the Des Moines TQM workshop made seven recommendations for quality improvement in the construction industry (1, pp. 55-61).

•Owners must take the lead. They will be

the driving force behind the implementation of TQM in the construction industry. Participants agreed that, in order to get the TQM process going, owners must require that formal TQM programs be in place at all of their contractors and designers. Owners should set very clear quality objectives at the project inception. If the owner is not clear about his quality objectives, he should not expect that his objectives will be met.

•Owners' requirements must be defined. The owner-designer-constructor team must work together to adequately define the owner's requirements. Once the owner's requirements are defined, the team can then work to design and construct a facility which satisfies those requirements.

•Training for all employees. There must be more training for all owner, designer, and contractor employees. The subjects which are most needed are technical skills, communication, interpersonal relations, and problem solving.

•Commitment to TQM by all team members. In order for the improvement process to be successful, the entire team must be committed to the ideals of TQM. Team members should be selected from companies with formal TQM programs.

•Identification of the cost of rework. Workshop participants revealed that many did not know the cost of rework in their companies, and they believed that this is typical for the industry. To realize the benefits of a quality management program, and to provide a statistical base for measuring improvement, firms must know how much they are currently spending for rework. One participant stated that, "We found that rework, in most phases of a project, cost about six times as much as the original cost of the installation."

•Measurement of customer satisfaction. One way to understand and measure the expectations of the customer is to initiate customer satisfaction surveys. This allows a better understanding of customer needs, expectations, and opinions. It also demonstrates to the customer that the company initiating the survey is interested in customer satisfaction.

•Management must enable all employees to do their jobs. They must provide the proper environment, tools, materials, and equipment to allow their employees to perform their tasks in a quality manner. Management must also allow the employees to have a greater say in determining how they will accomplish their tasks. This requires more training in technical skills, measurement, evaluation, and communication. The individual worker best understands his or her process. Most workers have the desire to do their job right the first time. Management's job is to empower their employees to be able to do this.

•Continuing improvement. Short term gains are not enough. There is always room for more improvement.

The application of TQM to construction offers some challenges, and will require some experimentation. One of the most significant challenges is the nature of the "construction project." Most projects are prototypes involving a different design, a different site, different weather conditions, different owner, designer, general

contractor, sub-contractors and suppliers, a changing workforce, different combinations of materials, etc. Nevertheless, the participants of the Des Moines TQM workshop believed that the concepts of TQM are sound and they are applicable to the construction industry if they are applied wisely, taking into consideration the prototypical nature of construction projects.

A project which has received accolades for the quality manner in which it was designed and constructed was the electronics manufacturing complex in Huntsville, Alabama, built for the Acustar subsidiary of Chrysler Motors. Lockwood Greene Engineers, one of two engineering firms on the project received Chrysler's Pentastar Award for superior performance on the project (9). Lockwood Greene attributes the success of that project to the firm resolve and guidance on the part of the owner that it would be a quality project, and to the extraordinary teamwork by all concerned (10). On the part of the owner, there was an unrelenting, continuous commitment to quality, active project leadership which infused everybody with their quality expectations, delegation of responsibility to a manager who took an active role in the project, daily participation in the design development by the owner, a constant search for potential problems to prevent them from happening, and timely and equitable resolution of problems that did occur. The designer team obtained the owner's requirements and expectations, thoroughly planned the work in concert with the owner, promoted in-house teamwork, controlled and checked every phase of the development of design, and continued the process with an intense design advisory service during construction. The general contractor was also awarded the Construction Management portion of the project as well. All members of his workforce, including those of the subcontractors, became involved in the quality process. Craftspersons were encouraged to contribute to improvement ideas.

Texas Instruments has also had success in implementing quality management in the construction of their facilities (11). They organized a construction quality improvement team in 1985 to develop ways to apply TI's successful quality programs in the manufacturing and service areas to the design and construction of their facilities. There are four features to the program they have developed: quality attitude, quality management, cleanliness and safety. To promote a quality attitude, they sponsored quality workshops for a selected group of general contractors. Both general contractors and selected subcontractors were required to complete quality orientations conducted by TI before they were permitted to bid on TI projects. The result has been a better understanding of TI's quality requirements and a better quality attitude during the bidding process. In addition, quality orientations for every worker performing work on a TI job are required. A Quality Manager who is an employee of the general contractor, is required. These quality managers ensure that work is performed in strict accordance with the plans and specifications. The quality manager reviews shop drawings to ensure they are properly prepared. The manager follows through on revisions to make sure all appropriate people are informed and that the site is continuously kept clean and orderly. The quality manager has the ultimate authority for quality. If work to be

performed does not meet the plans and specifications, he can advise the general contractor or subcontractor to correct the deficiency and may stop work when necessary.

The TI cleanliness program insures a clean, neat and orderly job site, so that workers can perform their job without interference. Part of that cleanliness program is to provide a separate, air-conditioned lunchroom for all workers on the job site. No food or drinks other than water are allowed in the actual work area. The lunchroom is also a place to provide additional quality awareness through bulletins, posters, and an electronic message board which mixes quality information with sports events and weather reports.

The safety portion of the TI program concentrates on adherence to OSHA standards. This includes wearing proper safety equipment and clothing. Drug testing is also required of all employees who work on TI facilities.

From the beginning, TI has believed that "Quality is Free," as preached by Philip Crosby. (Philip B. Crosby is a noted authority on quality management, and is author of the book Quality is Free.) The cost to the construction contractors who work on a TI quality job should be less because the amount of rework and warranty work should be reduced. Both general contractors and subcontractors confirm that their cost to work on TI jobs is less than on other jobs. Schedules are met more often, and as a result, job overhead costs are reduced.

When TI first started the construction quality process in 1985, non-conformance was about 12%. Since then, the cost of non-conformance has been reduced to less than 2%. Their goal, in keeping with continuous improvement, is to eliminate the cost of non-conformance.

One of the better references available on the application of TQM to the construction industry is a pamphlet entitled Total Quality Management: The Competitive Edge, published by The Construction Industry Institute in April 1990 (12). It is based on interviews with 142 individuals in 19 owner and contractor firms involved in constructing heavy industrial, manufacturing and commercial facilities. They found that of the eight owners and eight major contractors interviewed, six of each are taking a formal TQM approach to quality improvement. None of the three medium size contractors (1987 construction volume = \$20-\$100 million), have a formal TQM approach, but are instead following an informal TQM approach, i.e., many TQM concepts and methods being used.

Some of the summary recommendations of the study include (12, p. v):

- "Develop a corporate TQM program by thoroughly investigating the different approaches offered by various consultants/theorists and selecting the aspects of each one that apply to the specific needs of a particular company."

- "Educate management first, as managers must full understand and support the TQM process and actively participate in its implementation."

- "Address both the technical and humanistic aspects of TQM in the training effort."

•"Tailor training to the job functions of the employees."

•"Use pilot projects early during implementation to obtain management and employee acceptance of TQM."

•"Develop closer, more productive relationships among owners, contractors, subcontractors and vendors to create a team attitude toward improving quality."

CII states that instituting TQM involves three distinct phases: motivation, investigation and development, and implementation. Most contractors and owners were motivated by increasing competition and customer pressure. In the investigation and development phase, all but one of the companies formed a steering committee to select or develop an approach to quality improvement. Coordinators, knowledgeable in TQM, assisted the steering committees. Four of the companies interviewed were well into the implementation phase. Their quality organization included steering committees and process improvement teams. They had also begun their training programs.

According to CII, "both owners and contractors are seeking to build cooperative, team relationships with each other and with vendors and subcontractors... Some owners are requiring contractors to institute TQM on projects. In cases where an owner has TQM and the contractor does not, the owner may assist the contractor in getting started, but may not want to pay directly for the implementation efforts of the contractor (12, p 13)."

The CII study points out that "three contracting methods are frequently mentioned as preferable in terms of providing a quality project, namely, design-build, partnering, and incentive. Owners are establishing partnering agreements with selected contractors. Both owners and contractors are identifying and eliminating poor performers among qualified vendors, while building closer, more productive relationships with those remaining (12, p. 13)."

The Des Moines workshop and the CII study both show that TQM is in various stages of development in our construction industry. There is significant evidence to show that TQM has been successfully applied to the design and construction process.

THE AGC OF AMERICA APPROACH TO TQM

In early 1990 the Associated General Contractors of America (AGC) took up the TQM banner through the creation of a Quality Management Task Force. This Task Force has used 1990 to analyze the needs of AGC's members, examining the existing industry programs, and developing an agenda for a full fledged AGC national committee on Quality Management. At the AGC annual meeting in March 1991, the Task Force completed their work by recommending the creation of a national committee and by sponsoring a panel discussion on Quality Management at the annual meeting of the Building Division of the AGC. This is a first step in raising the level of awareness of this subject in the minds of AGC's membership of 8,000 general contractors and 10,200 national

associate members.

Through its work, the Quality Management Task Force realized that the construction industry was behind the curve in the application of quality management concepts. TQM programs were not at all prevalent. There were a few hundred contractors who are ahead of the pack; but for the most part, the majority of contracting firms have not even begun to consider TQM.

The Task Force identified their first step as one that would be focused on awareness. Yes, there is an abundant amount of discussion about desiring quality results; but there is not as much talk or thought about the follow-up issue of how to go about achieving those results. What is the process that will lead to higher quality? How do you implement a program? How can TQM help a company become more successful?

Raising and answering these questions are the first steps in creating a major movement in our construction industry directed towards creating a higher standard of quality in our industry.

Following the awareness phase, AGC efforts will then be devoted to an education phase, which will focus on "how to" implement a TQM program. This phase will begin by looking at successful applications of TQM programs in other industries and the successes within the construction industry. When this education phase gets underway and when the construction industry leaders set the example for others to follow, AGC will be on their way to creating a more successful and respected industry.

CONCLUSION

There are many problems in the construction delivery process, and all parties to the construction process must shoulder some of the responsibility. Quality in our projects is what everybody wants, but too often we are unable to deliver. Certainly, project costs need to be competitive and the time of delivery must be reasonable; but in the end, the quality of the project is what the client lives with for many years following completion of the construction. This is what the construction industry clients are asking for ever more loudly.

There is no need to continue this no-win situation. It would appear that all parties stand to benefit by implementing TQM within their organizations, and by requiring their suppliers to do the same. Although some designers and contractors may start on their own, owners, both public and private, could accelerate the process by requiring their designers and contractors to develop TQM programs. They could then require evidence of these TQM programs as a prerequisite to consideration for selection.

Designers, contractors and suppliers need not wait on owners to take the lead. They should be proactive and establish their own TQM programs, tailored to their own specific needs. The AGC of America movement in this direction is a positive first step.

TQM offers an opportunity to resolve many of the problems that plague the construction industry. All participants in the construction process should help the industry move toward full implementation of TQM.

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Total Quality Management in the Source Selection Process

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ABSTRACT

The present thinking of incorporating Total Quality Management (TQM) into the source selection process addresses the Malcolm Baldrige National Quality Award criteria. This is a logical approach, considering standardization on a national level, but using this criteria to evaluate a contractor's quality improvement activities introduces some significant problems.

Consider two of the seven major categories; Leadership and Human Resource Utilization. It takes a wealth of experience and information for anyone outside an enterprise to assess these areas.

This paper reviews the background of quality in source selection, cites a recent recommendation of integrating TQM (as defined by the Malcolm Baldrige criteria) in source selection, and presents findings and conclusions from a recent survey of Malcolm Baldrige Examiners.

INTRODUCTION

Recently there has been talk about putting quality criteria into the source selection process. Within the Department of Defense (DOD), we continually exhort that only lowest bidders are awarded contracts and that not to do so would break the law. In this paper, initially I will resolve that the lowest bid is not the sole criteria for awarding contracts. Second, I will show how quality (i.e. TQM) is considered seriously and, in a few cases, is a key element in assessing bidders for award. Last, since present thinking defines TQM in terms of the Malcolm Baldrige National Quality Award criteria, I will define problems related to using this criteria.

The Malcolm Baldrige criteria was developed primarily with commercial U.S. industry in mind. In fact, out of 183 examiners in 1990, I could identify only 10 related to the defense business; only one was with the DOD.

Examiners are individuals who evaluate submitted applications, score paperwork, and conduct site evaluations of finalists. I will present results and my conclusions of a survey conducted with the help of seven Malcolm Baldrige examiners. The purpose of the survey and my personal investigation *is to determine problems* with using this criteria, and to recommend solutions.

Quality as a Factor in Source Selection

Government policy guidance for formal source selection is provided in Federal Acquisition Regulation (FAR) 15.612. It requires formal designation of a responsible official as source selection authority, formal establishment of an evaluation organization, and preparation of a source selection plan. Furthermore, FAR 15.605 Evaluation factors, state in part:

(a) The factors that will be considered in evaluating proposals should be tailored to each acquisition and include only those factors that will have an impact on the source selection decision.

(b) The evaluation factors that apply to an acquisition and the relative importance of those factors are within the broad discretion of agency acquisition officials.

However, price or cost to the Government shall be included as an evaluation factor in every source selection. Quality also shall be addressed in every source selection. In evaluation factors, quality may be expressed in terms of technical excellence, management capability, personnel qualifications, prior experience, past performance, and schedule compliance. Any relevant factors, such as cost realism, may also be included.

(c) While the lowest price or lowest total cost to the Government is properly the deciding factor in many source selections, in certain acquisitions the Government may select the source whose proposal offers the greatest value to the Government in terms of performance and other factors. This may be the case, for example, in the acquisition of research and development or professional services ....

During the years, Military Specification MIL-S-9858A was implemented widely under contract and provided "prior experience and past performance" data. More recently, many uncoordinated Service efforts have been made to insert prescriptive quality language into the request for proposal (RFP).

TQM in Source Selection

In April, 1989, the Under Secretary of Defense (Acquisition) chartered a Process Action Team (PAT) to recommend appropriate DOD policy and guidance to integrate TQM into the source selection process. The multidisciplined PAT had representation from:

OASD(P&L) PR
OASD(P&L) P
ODUSD(TQM)
OUSD(DDR&E)
OSD General Counsel
Army
Navy
Air Force
DLA
DCA
DSMC.

Their actions resulted in generation of the Guide to Integrating Total Quality Management into Source Selection, May 8, 1990, Draft Working Paper. This document calls for:

- -TQM in the Acquisition Plan (AP)
- -TQM in the Source Selection Plan (SSP)
- -Insertion of TQM language in the Request for Proposal (RFP)
  - -Executive Summary
  - -Instructions to Offerors
  - -Evaluation for Awards
- -Conducting the Assessment of Performance Risk
- -TQM (i.e., Continuous Process Improvement) During Contract Execution

TQM in the Acquisition Plan

The AP should include an overview of the approach, suggested in the Guide, to incorporate a Performance Risk Evaluation (including TQM, past and present) as part of the source selection.

TQM in Source Selection Plan

The SSP is a key document for initiating and conducting source selection. It is prepared by the program office and approved by the Source Selection Authority (SSA). The SSP should provide the details about evaluation methodology to be used in assessing Performance Risk (refer to Section V of this guide for further information on conducting the assessment of Performance Risk).

The SSP should also stipulate the specialized training requirement of the performance risk evaluators for the Source

Selection Evaluation Board (SSEB) and the Source Selection Advisory Committee (SSAC).

<u>TQM in the Request for Proposal (RFP)</u>

Sample Language

<u>A. Executive Summary of RFP</u>

" The Government intends to consider each offeror's application of continuous process improvement principles. Specifically, a Performance Risk Assessment will be conducted to assess the effectiveness of the offeror's continuous process improvement effort and successful application, demonstrated in terms of results."

<u>B. Section L - Instructions to Offerors</u>

1. The sample instruction to offerors (below) is premised on the Malcolm Baldrige Quality Award Guidelines (Appendix A). It was developed by reducing the Malcolm Baldrige criteria in scope and detail and adding DOD-oriented language....

<u>Volume XX - Information for Assessment of Performance Risk, Including Results of Continuous Improvement Efforts</u>

<u>Note: The use of a separate volume, while not mandatory, is strongly recommended to obtain proper visibility and to focus on continuous process improvement and past and present performance.</u>

<u>This volume may be marked "Source Selection Sensitive" and will be treated accordingly by the Government.</u>

1.0 General (same as summary)

1.1 Page Limitation

1.2 Specific Information and Data

1.2.1 The offeror shall provide the information below emphasizing documented, verifiable evidence of past and present performance, demonstrated in terms of results and documented, verifiable evidence of the effective implementation of continuous process improvement efforts. Action presently planned may also be included. Information provided should be....

1.2.2 The following information and data shall be included:

a) the offeror shall describe the application of continuous improvement practices, tools and techniques, and where available, the offeror should submit a past and present performance record demonstrating achievement on relevant contracts. The offeror shall, in addressing the specific areas described below, provide cross-reference with the appropriate paragraphs of the Technical, Management, Logistics, etc., proposal volumes, which indicate where continuous process improvement practices, tools, and techniques are applied. (The Technical, Management, Logistics, etc., proposal volumes may also cross-reference with the Performance Risk volume.) The offeror's proposal should address the following areas:

1) <u>Leadership</u>. Describe how senior executives create and sustain a clear and visible quality value system along with supporting continuous process improvement management system to guide all activities of the company.

2) <u>Information and Analysis.</u> Describe and demonstrate the scope, validity, and management of data and information that underlie the company's continuous process improvement management system. In particular, describe

how the company uses data to support a prevention-based approach to quality.

3) Strategic Quality Planning. Describe the company's short and long term continuous process improvement priorities and plans to achieve them.

4) Human Resources Utilization. Describe the company's practices to develop and utilize the full potential of the work force and to maintain an environment conducive to full participation, continuous process improvement and personal and organizational growth. Summarize 1) recent trends in employee participation in continuous process improvement activity, 2) types of continuous process improvement education and training provided in each pertinent employment category, and 3) trends in recognizing employees for contributions to continuous process improvement.

5) Quality Assurance of Products and Services. Describe how products and services are continuously improved through optimization and improvement of processes. In the area of design and development, where applicable, the description may include information pertaining to the use of continuous process improvement techniques such as quality function deployment, producibility engineering and planning, design of experiments, DOD Directive 4245.7M - Transition from Development to Production, etc. Include a description of how the offeror flows the company's continuous process improvement focus down to subcontractor levels.

6) Quality Results. Provide data that shows trends in: a) improvement of quality of products and services based on analysis of customer requirements, analysis of quality deficiency reports, cycle time reductions, Material Review Board actions, scrap and rework, etc., and analysis of internal business operations; and b) improvement in the quality of supplies and services furnished by other companies. Provide evidence of using quality results to overcome and prevent problems of quality. Demonstrate application of the offeror's continuous process improvement activities by summarizing projects that illustrate their breadth and effectiveness. The offeror also should submit information on contracts relevant in demonstrating ability to perform the proposed effort. This may include data on efforts of other divisions, corporate management, critical subcontractors, or teaming subcontractors - - if such resources significantly influence performance of the proposed effort. For each current or past contract deemed relevant, the offeror should provide the following information:

a) Administrative Data
(1) Company/Division Name
(2) Program Title
(3) Contracting Agency
(4) Contract Number
(5) Brief description of the contract effort, indicating whether it was development and/or production
(6) Type of Contract
(7) Period of Performance
(8) Original Contract Dollar Value and Current Contract Dollar Value
(9) Original Completion Date and Current Completion Date
(10) Name, address, and telephone number of Government Program Director/Manager, Administrative Contracting Officer (ACO), and Procuring Contracting Officer (PCO).

b) Specific Content. Offerors are required to explain aspects of contracts relevant to the proposed effort. Categorize the relevancy determination into the specific evaluation areas used to evaluate this proposal; e.g., continuous process

improvement. Offerors also are requested to submit information on significant achievements, or explain past problems considered relevant to the proposed effort.

7) Customer Satisfaction. Describe the company's methods for determining customer satisfaction. Summarize the company's customer satisfaction trends.

C. Section M - Evaluation Factors for Award

1. The language for Section M should be covered in two parts:

a. General Basis for Award - This section describes how the solicited proposals will be evaluated and ranked.

b. Performance Risk - This section describes how Perfc-mance Risk will be assessed.

2. Sample language for Performance Risk follows:

The Government will also conduct a Performance Risk assessment based in part on: 1) effectiveness of the offeror's continuous process improvement effort and the effectiveness of the offeror's use of continuous process improvement practices, tools, and techniques as applied to the proposed contract, and 2) the offeror's past and present performance record, demonstrated in terms of actual results. In assessing Performance Risk, the Government will use information and data as submitted by the offeror, as well as information and data obtained from other sources, to evaluate the areas listed above. If discussions are held, the offeror will be given the opportunity to review and respond to the data obtained from other sources. Performance Risk assessment relates to the offeror's probability of successfully accomplishing the proposed effort.

Malcolm Baldrige National Quality Award Criteria in the Source Selection Process

The Guide to Integrating Total Quality Management into Source Selection **simply a guide, not a directive.** It is a logical and timely direction for the DOD to take.

Total Quality Management (TQM) this Guide is translated into Malcolm Baldrige National Quality Award (MBNQA) criteria, known internationally. In September 1990, as keynote speaker at the 34th Annual Conference of The European Quality Organization, Dr. Joseph Juran, world-renowned quality expert, predicted the United States again would be preeminent in quality in the 1990s. This prediction was based on the national impact of the Malcolm Baldrige National Quality Award.

Using MBNQA criteria should provide the DOD meaningful and universal standards to measure Quality/TQM effectiveness of outside contractors, and to use internally. There are things to be done before this guidance can be deployed throughout the Department of Defense and the defense industrial base.

The survey conducted with MBNQA examiners provides much insight on advantages and disadvantages of blindly and untutored implementation of the criteria for awarding contracts. Individual responses to the survey can be found in Appendix B.

CONCLUSIONS

Summary

The Draft guide lists seven Malcolm Baldrige criteria to use for Assessment of Performance Risk. It indicates this assessment should be conducted by a special assessment team, and that and a summary of the potential performance by

the contractor should be developed. This assessment of the contractor's (potential for success, with additional information), will go to the Source Selection Authority Council or the Source Selection Evaluation Board.

The Source Selection Authority (SSA) will use the risk assessment in addition to results of the ranked evaluation factors of Cost, Technical, Management and Logistic proposals to make an award selection. The precise way for the SSA to integrate risk assessment into the process is not determined.

The suggested general manner in which the MBNQA performance risk assessment data can be used should be developed. Using this criteria suggests the need to allocate point count to categories (see Appendix A); if this is done the allocation scheme should be published.

Following are specific advantages and disadvantages derived from the survey. A complete set of responses is included in Appendix B. Major work needed before widespread utilization involves:

- A system of evaluator selection, training and assessment should be jointly developed with industry.

- As suggested in the Guide, pilot implementation should be conducted and non-proprietary results published.

- Developing a method, conducive to contractor concurrence, for verification of findings.

Conclusions

Advantages

1. The MBNQA criteria, used in a none prescriptive manner provides flexibility to the government and industry.

2. Elevates the business of quality improvement to managements' policy, direction and actions.

3. Promotes concurrent engineering and defect prevention thinking.

4. Should stimulate utilization of the best commercial practices in the defense business.

5. Will stimulate quality improvement planning at corporate levels.

6. Allows companies with defense and commercial businesses to have one set of quality books.

Disadvantages

1. The MBNQA criteria for Performance Risk Assessment presented for consideration to SSA or SSEB requires additional definition.

2. A method, agreeable to contractor's, for data verification is required.

3. Legal review of data implications, on pilot implementation, must be conducted.

4. Employee empowerment and team participation may be restrained due to contractor cost accountability.

5. Use of MBNQA criteria will fail unless well-qualified and trained people perform the assessment.

The responses from the Malcolm Baldrige examiners in Appendix B provide PROs and CONs on the subject. Very little editing has been done on their input.

1991 EXAMINATION CATEGORIES AND ITEMS

Malcolm Baldrige National Quality Award

1991 Examination Categories/Items		Maximum Points
1.0 Leadership		**100**
1.1 Senior Executive Leadership	40	
1.2 Quality Values	15	
1.3 Management for Quality	25	
1.4 Public Responsibility	20	
2.0 Information and Analysis		**70**
2.1 Scope and Management of Quality Data and Information	20	
2.2 Competitive Comparisons and Benchmarks	30	
2.3 Analysis of Quality Data and Information	20	
3.0 Strategic Quality Planning		**60**
3.1 Strategic Quality Planning Process	35	
3.2 Quality Goals and Plans	25	
4.0 Human Resource Utilization		**150**
4.1 Human Resource Management	20	
4.2 Employee Involvement	40	
4.3 Quality Education and Training	40	
4.4 Employee Recognition and Performance Measurement	25	
4.5 Employee Well-Being and Morale	25	
5.0 Quality Assurance of Products and Services		**140**
5.1 Design and Introduction of Quality Products and Services	35	
5.2 Process Quality Control	20	
5.3 Continuous Improvement of Processes	20	
5.4 Quality Assessment	15	
5.5 Documentation	10	
5.6 Business Process and Support Service Quality	20	
5.7 Supplier Quality	20	
6.0 Quality Results		**180**
6.1 Product and Service Quality Results	90	
6.2 Business Process, Operational, and Support Service Quality Results	50	
6.3 Supplier Quality Results	40	
7.0 Customer Satisfaction		**300**
7.1 Determining Customer Requirements and Expectations	30	
7.2 Customer Relationship Management	50	
7.3 Customer Service Standards	20	
7.4 Commitment to Customers	15	
7.5 Complaint Resolution for Quality Improvement	25	
7.6 Determining Customer Satisfaction	20	
7.7 Customer Satisfaction Results	70	
7.8 Customer Satisfaction Comparison	70	
TOTAL POINTS		1000

Appendix B

RESULTS OF SURVEY

LEADERSHIP

PRO

Management demonstrates use of quality technologies

Management shows involvement and commitment

Gives idea of contractor ability to control processes

Illustrates commitment backed by proven track record

Management should demonstrate involvement
- time spent
- activities involved in.

CON

If audit does not include input from first and mid-level management the input could be a snow job

Requires massive training and change in strategy

Difficult to assess objectively - up to examiners judgement

Must be examined carefully to avoid gamesmanship

Government must understand bidders processes and must have quality zeal equal to contractor.

INFORMATION AND ANALYSIS

PRO

Promotes the use of quantifying and using data to make statements

Could use this area without much change

Measures efficiency and effectiveness of the infrastructure

Assessment of system should indicate adequacy for quality improvement.

CON

Not appropriate for service industries

Should not be an end to itself. Need dictates size and complexity of system

Difficult to obtain relevant data

Requires a high level of Government sophistication with regard to validation of measurements to national or world-class benchmarks

Must be careful not to use laundry list.

STRATEGIC QUALITY PLANNING

PRO

Examples should be included

Helps to assess the priority of Quality within an operation

Critical for maintaining and improving capabilities. Should be in place already

Corporate strategic plans and subsets of business plans, quality plans - all areas (whether manufacturing or service) require planning and communicate the plan

Vital cornerstone of any well organized company. Tells much about historical track record as it speaks to future plans.

CON

Performance to plan is difficult to evaluate

The evaluator will need to look beyond the paper work and check the process

Includes long-term, and may include areas and subjects not considered important to Government. May recommend technology requiring long-term payback

Should not be an end to itself. Although strategic planning may be a generic process it may be applied very differently by different program managers

Would require extensive benchmarking and use stretch goals and detailed annual improvement plans to support Strategic Plan. Could be extremely negative for some companies, where past performance has resulted from single/sole source contracts where profit is established as a percent of costs.

HUMAN RESOURCE UTILIZATION

PRO

Probably the most powerful measure of companies operational efficiency and management effectiveness

This category critical to success of any business and should be used

Difficult to judge objectively. Some elements can be extracted, e.g. workmanship, technical training, etc.

Empowering people very important part of TQM

Well trained individuals with proper skill mix reduce risks.

CON

Would require extensive descoping of current criteria in order to sustain even a small fraction of the current military industrial base

Leans towards micro management

Military discipline and DoD structure can impair employee involvement. Simple concerns as to where to charge team spent in teams may deter use. DoD systems must support resources being spent on involvement, training and recognition

Quality of work life issues are very subjective.

QUALITY ASSURANCE OF PRODUCTS AND SERVICES

PRO

Provides a comprehensive set of metrics for determining company-wide progress

It is critical that key systematic approaches are in place in a prevention mode and to assure quality. Not the traditional control DoD systems that call for inspect it in quality

Appropriate for manufacturing or supply of products. Service applied to this category associated with manufacturing

Examines both control and improvement of quality

This has been traditional area for DoD through Mil. Stds., therefore, Baldrige will provide flexibility

Proven process control reduces risk of future production.

CON

Uniformed evaluator could be overwhelmed. All the government measures of Contractor quality focus on (5%) "touch labor"

Gives government tool to abuse contractor if misused

Do not create Mil. Std. to address Baldrige

Must be careful to avoid gamesmanship.

If assessors are too rigid or prescriptive they may not recognize good unique approaches.

QUALITY RESULTS

PRO

Very important and an area where DoD should emphasis in awarding contracts

Past results are good indicators of future successes

Most suitable for use in source selection. This gives a quality indicator before it reaches customer hands

Results are the bottom line measure of how well company can be expected to perform on future contracts

Gives bid evaluators and contract administrators concise, focused, yet comprehensive information regarding health and management of contracts

Appropriate for manufacturing. This category examines quality levels and quality improvement based upon objective measures derived from analysis of customer requirements and expectations and from analysis based on operations.

CON

Be wary of gamesmanship

Need a method to ensure contractors present data honestly

Government reviewers must be able to validate the legitimacy of claimed results through intense examination of the systems and processes which bear a causal relationship to the results

DoD and industry should get together and develop measurement techniques and specify benchmarks.

Must be careful not to look for functionality alone. Products' quality should be tied back to robust systems that assure price and service quality as well.

CUSTOMER SATISFACTION

PRO

Examines company's knowledge of the overall customer service systems, responsiveness, and its ability to meet requirements and expectations. Also examined are current levels and trends critical to source selection process

Good summary statement of company's management health

Very quantitative category and could be used in source selection

Special weighting should be given to DoD customer satisfaction.

Critical because it is ultimate quality measure.

CON

Service industry needs work in developing numerical or metric levels

Measurement of Company-wide Quality, timeliness, cost performance relative to world-class benchmarks are difficult. Few Defense Contractors could measure up to a legitimate yardstick in this area

Definition of customer satisfaction measurement is a problem

Be wary of gamesmanship.

This can be confusing for a supplier because of the many customers he serves. The ultimate customer, the user, can be forgotten. Government regulations sometime do not permit critical conversations between supplier and customer. Because of concerns about unfair competition, much of the early conversations are prohibited or appear threatening.

INTERGRATING QUALITY CONSIDERATIONS IN THE SYSTEMS ACQUISITION PROCESS

Dr. James H. Perry, The George Washington University

ABSTRACT

This paper examines the use of quality information in systems acquisition decisions by incorporating specific quality factors in a simple analytical model designed to provide the buyer with the capability to appropriately consider quality differences in reaching a cost-effective acquisition decision. Initially, dimensions of quality are identified and discussed based on the parameters proposed by David Garvin. Using the Garvin framework, the paper then reports the results of an extensive survey of NAPM professionals in which the general feasibility and desirability of explicit consideration of quality factors in the systems acquisition process are firmly established. Finally, the paper extends the consideration of specific quality factors by introducing and illustrating an analytical approach that effectively incorporates quality differences in a structured and auditable model that projects the cost implications to the firm of the quality differences identified. Based on the results of the analysis, it is concluded that not only is quality an important factor in many systems acquisition decisions, but that generally-accepted dimensions of quality can be identified and applied in an operational mode to assist the buyer in making the most desirable acquisition decision.

INTRODUCTION

Systems acquisition typically involves a complex ranking and evaluation of objective and subjective factors. These factors may be addressed explicitly in the form of objective criteria or implicitly based upon judgment or taste. Both personal and commercial/industrial acquisition are focused on the "classical" objective:[1]

> To buy materials and services of the right quality, in the right quantity, at the right price, from the right source, and at the right time.

In personal purchasing, selection may be completely subjective based on a mental evaluation of how a given product meets the personal requirements of the individual. The selection process is unstructured, may change over time, and only needs to satisfy the individual. Information about competing products is difficult to obtain and, for many products, insufficient past personal experience about the product exists. By comparison, in most commercial or industrial buying, the acquisition process is structured in method, centralized to some extent to provide consistency, and open to audit and review. The buying office takes written requirements from the requesting office, matches them with available suppliers, and negotiates the most favorable terms for the acquisition. Success in achieving the objective of selecting the right quality is important to the efficiency and effectiveness of the firm and, for repetitive requirements, suppliers establish a track record of performance that can be used in making subsequent acquisition decisions.

QUALITY: WHAT IS IT AND HOW CAN IT BE BOUGHT?

In personal purchasing decisions, we all believe that we are excellent judges of quality, be it by an established name of the manufacturer or our own knowledge of the product. However, when pressed

for a universal definition of quality, some qualification will no doubt take place and before quality can be used routinely in purchasing decisions, a uniform definition must be established. Thus, to develop a consistent operational understanding of quality, we briefly review alternative quality definitions.

GARVIN'S APPROACH TO DEFINING QUALITY

David A. Garvin has proposed the following five approaches to defining quality:[2]

- The *Transcendent Approach* is the philosophic concept of "innate excellence," which is both absolute and universally recognized. It cannot be analyzed but is recognized through experience.

- The *Product-Based Approach* focuses on the quantity of some ingredient or attribute possessed by a product. As in the amount of cream in ice cream, it can be assessed objectively and is based on more than preferences alone.

- The *User-Based Approach* begins with the premise that quality "lies in the eyes of the beholder." Through maximization of the composite individual preferences, a "proper" quality is determined. It is subjective and rooted in consumer preferences.

- The *Manufacturing-Based Approach* focuses on engineering and manufacturing practices. It identifies quality as "conformance to requirements," and it is equated with meeting specifications or making a product right the first time.

- The *Value-Based Approach* defines quality in terms of costs and prices. Quality provides performance at an acceptable price. The phrase "affordable excellence" summarizes the dilemma. There are no defined limits and no means of application.

In assessing these alternative definitions of quality, it should be noted that the approaches often conflict or overlap and, depending on the perspective taken, may lead to disparate conclusions. For example, under the **product-based** definition of quality, we expect to pay more for quality because we expected that better materials, workmanship, and inspection were applied to achieve this quality. Theoretically, from the product-based paradigm, there should be a positive correlation between the price and quality of an item. This is a marketable attribute–regardless of whether it is based upon fact, reputation, or simply impression–that can be applied when marketing under the user-based perspective. The lack of precise information on the true attributes of the product encourages managers to set higher prices to "imply higher product quality."[3]

Within the **user-based** paradigm, quality is an attribute by which consumer goods are marketed. Many products are marked using adjectives such as "choice," "select," "prime," "superior," or "distinctive" to demonstrate the perception that quality is important and valuable.

To illustrate the **manufacturing-based** approach, consider the U.S. auto industry.[4] Slogans such as "the quality goes in before the name goes on" and "quality is job 1" are indicators of the importance of quality in the production process in the industry. Ford Motor Company, for example, has adopted a "defect prevention" approach to quality which, while manufacturing-based, has yielded dramatic quality improvements,

and has boosted Ford's standings in consumer quality ratings.[5]

Finally, numerous studies have shown that in many consumer products, people will pay a premium for real or perceived quality.[6] In such simple items as a pen or a pencil, suitable **value-based** products can be found for under a dollar, while there are also many value-based products marketed at a much higher price. Production management and quality sampling techniques, which operate under the manufacturing-based definition, can ensure that the established quality standards for both the Number 2 wooden lead pencil and precision drafting pencil are maintained. However, the premium that will be paid for quality is determined by the market mechanism within the user-based[7] definition.

Thus, our dilemma in seeking a single uniform definition of quality is clear from the following "tongue-in-cheek" summary: Quality can be considered the *transcendent* judgment of *product-based* attributes developed through the *manufacturing-based* process, which seeks to provide *value-based* products whose worth is determined by the *user-based* market under information uncertainty.

DEFINING QUALITY BY ITS COMPONENTS

Recognizing the difficulty of finding a single suitable definition which could be used to evaluate quality differences, Garvin has segmented quality into the following eight component dimensions:[8]

- *Performance* refers to the operating characteristics of the item.
- *Reliability* reflects the probability of a product being available for use or falling within a specific period of time.
- *Serviceability* is the speed, accessibility, and ease of repairing the item or having it repaired.
- *Conformance* is the degree to which delivered products meet the preestablished standards.
- *Durability* measures the projected use available from the product over its intended operating cycle before it deteriorates.
- *Features* are the "bells and whistles" or secondary characteristics, which supplement the product's basic functioning.
- *Aesthetics* reflects personal judgment of how a product looks, feels, sounds, tastes, or smells.
- *Perceived Quality* is closely identified with the reputation of the producer. It, like aesthetics, is a personal evaluation.

While the weight placed on any single dimension or characteristic identified above will vary based on the nature of the item being bought, quality dimensions of performance, reliability, conformance, durability, and serviceability will likely be important factors for most systems acquisition decisions. But, to what extent can these factors be isolated and applied reasonably in the acquisition decision-making process? To determine the acceptability of these quality dimensions and to assess the application of the concepts, we now turn to an empirical examination of the issue.

SURVEY OBJECTIVES AND METHODOLOGY

To judge the feasibility of explicitly considering specific dimensions of product quality, a random sample mail survey of almost 1,200 National Association of Purchasing Management (NAPM) members was conducted in the

summer and fall of 1988. The specific objectives of the survey were as follows:

(1) To identify, rank, and evaluate the dimensions of quality suggested by Garvin;

(2) To determine the feasibility of applying these quality dimensions in the acquisition process; and

(3) To evaluate the quality feedback loop and the effectiveness of warranties and other evaluation systems to measure or identify quality actually received.

Given the total NAPM membership of approximately 27,000 people, this large sample was adequate–with an assumed response rate of 33 percent–to represent the NAPM population at a 95 percent confidence interval. Actual survey response is indicated in Table 1 below.

TABLE 1

SURVEY RETURN STATISTICS

NAPM Membership	Number Surveyed	Number Returned	Response Rate
27,000	1,163	434	37

The response to the survey instrument is sufficient to consider the results representative of the population being surveyed.

SURVEY RESULTS

The data analyzed in this research is reported rather than observed. The respondents were asked to respond to questions concerning their attitudes and actions instead of looking at these actions and their results from an established data collection source. Recognizing this limitation, survey results are summarized in the following paragraphs.

Garvin's dimensions of quality were adapted to a military/industrial environment,[9] and respondents were asked to consider what price premium they would place on an improvement by ten percent for each of the dimensions identified. The possible range was between 0 and 25 percent and there was no budget restriction imposed. That is, giving a 25 percent premium was acceptable. The purpose of this approach was to determine if such quality measures were appropriate, and to establish the relative importance of the dimensions of quality in the systems acquisition decision. The results are summarized below in Tables 2 and 3.

Table 2 provides the relative ranking of factor importance for the dimensions of quality identified by Garvin and used as the basis for the survey. Clearly, reliability and performance were identified as the most important factors, but all four commercial or industrial factors demonstrated a positive relationship. Eighty-three percent of the respondents completed this section and provided at least two positive values for the factors.

TABLE 2

MEAN QUALITY FACTOR EVALUATION
(Percent Premium for 10 Percent Improvement)

Quality Factor	Mean
Reliability	8.3
Performance	8.1
Durability	6.7
Serviceability	6.3

In order to develop methods of measuring quality, it is important to

establish the feasibility of such measurement. When respondents were asked if quality could be objectively measured, the response was extremely positive. Table 3 displays the results compressing the categories to indicate agreement, neutrality, or disagreement with the question.

TABLE 3

QUALITY CAN BE MEASURED
Agreement or Disagreement in Percent

Neutral	Disagree	Agree
17%	7%	76%

Finally, in analyzing the survey results that addressed the adequacy of quality evaluation systems, there was general acceptance of the effectiveness of such systems by the acquisition community as demonstrated in Table 4.

TABLE 4

EFFECTIVENESS OF QUALITY EVALUATION SYSTEMS
(Percent Rating Them Good or Excellent)

Rejection on Receipt	72
Defect in Use	64
Delivery Delay	58
Warranty Claims	38

In summary, therefore, results of the empirical survey of NAPM professionals across a broad range of industries, products, and locations support the position that the identification of specific quality factors is feasible; that such factors can be effectively evaluated in the acquisition process and in assessing product quality received; and that performance, reliability, durability, and serviceability rank as the most important quality factors in most system acquisitions. The question remains, however, as to the appropriate methodology that will allow the buyer to explicitly consider these quality factors in a consistent, comprehensive manner to maximize the net benefit to the firm.

THE EVALUATION MODEL: CONCEPTUAL FRAMEWORK

Most system acquisitions must be justified based on an analysis of both costs and benefits received by the acquiring organization. While acquisition price is known, the total costs and related benefits to the organization over the life-cycle of the system are generally much less clear at the time of the purchase decision. Because the quality factors we have discussed above impact both benefits and costs to the acquiring organization, it is important to incorporate these factors directly into the cost-benefit analysis, which is the foundation of the actual acquisition decision. Using the concept of *Operating Effectiveness*, Perry[10] has developed an analytical model for decision-making that allows the buyer to consider quality factors of performance, reliability, durability, and serviceability in the acquisition decision. *Operating Effectiveness* is defined as the combination of performance, reliability, durability, and serviceability which uniquely establishes the expected operational results of a given system. By considering what the system is designed to do (performance), the period of time over which the system can be expected to perform without failing (reliability), the total projected operating life of the system (durability), and the speed or ease of repair when failure occurs (serviceability) in combination, the *Operating Effectiveness* of a given system represents an objective composite indicator of the expected quality contribution of the system.

To understand these relationships, it should be first noted that in the original exposition, Perry referred to performance as "capability" and durability as "dependability." Further, the model used both reliability (defined more specifically as the Mean Time Between Failure) and serviceability (defined more specifically as the sum of Mean Time to Repair and Mean Logistics Delay Time) to derive the projected *availability* of the system for use at any given point in time. Thus, *system availability*, in combination with *system performance* and *system durability*, directly determine the *Operating Effectiveness* of the system as shown in Figure 1 below. For example, consider a system capable of producing 100 units of output per operating cycle or period. Output metric would be a function of the specific system and the operating period could be a day, a sortie, etc. Thus, system performance is 100 units. Further assume that the system is expected to be "up" (i.e., system availability) 80 *percent of the* time and that, if the system is up at the beginning of an operating cycle, it is expected to complete the cycle (i.e., system durability) 90 percent of the time. For this system, the expected Operating Effectiveness would be 72 units of output per operating cycle (100 x .8 x .9).

Figure 1

OPERATING EFFECTIVENESS

System Performance	x	System Availability	x	System Durability	=	Operating Effectiveness

In most system acquisition decisions, there is a tendency to focus on either performance or cost. If attention centers on the best system, soon the increments of improvement–while real–fail to justify their expense. Conversely, if cost is the principal motivator, efforts center on meeting the minimum acceptable requirement. Achieving balance requires a clear understanding of achievable quality and cost realism. The expanded model above allows us to directly link the quality measures of performance, availability, and durability (via the operating effectiveness of each alternative system) with the projected costs (including price and relevant operating costs) of the system to evaluate alternatives based on net benefit to the acquiring organization. If there is a minimum or mandatory Operating Effectiveness required, the approach allows evaluation of those system alternatives that meet this minimum requirement at the lowest cost. However, the approach also facilitates the analysis of higher quality systems based on the relationship between the added Operating Effectiveness and the added cost associated with the system.

It is envisioned that an acquisition strategy using cost premiums would be employed in many cases. Rather than assigning a single Operating Effectiveness target, we therefore suggest placing a percentage premium on each quality dimension to examine the potential improvement in Operating Effectiveness from the base requirement. This premium percentage, which could vary based on the nature of the system acquired, would be specified by the buyer in addition to the cost differential ceiling allowed. The concept is illustrated by the following example. An equipment is needed that would have a projected Operating Effectiveness of 72 units per day. One alternative system meeting this requirement would be an equipment with a system performance of 100 units a day, an expected availability of .80, and a durability of .90. Recognizing that the Operating Effectiveness standard of 72 units per day must be met, but that price will be an important element in the acquisition decision, supplier firms will seek to merely achieve necessary quality parameters. However, providing an incentive feature for each quality variable encourages innovation and generates better Operating Effectiveness.

Conservatively using the information gained from the NAPM survey, which indicates the cost premiums that buyers considered appropriate, assume that a 5 percent increase in cost (or price) is authorized for attainment of a 10 percent improvement in each of the specified quality dimensions. Assuming that this is met, Operating Effectiveness would change as follows:

Figure 2

	System Perform-ance	x	System Avail-ability	x	System Dur-ability	x	Operat-ing Effec-tiveness
Orig. Pro-posal	100		.8		.9		72 units/ per day
Incent-tive Proposal	110		.88		.99		96 units/ per day

The question is, therefore, whether up to a 5 percent increase in price is worth a 33 percent increase (24 units per day) in operating effectiveness and which vendor meets the improved level of Operating Effectiveness with the smallest cost (or price) differential.

The potential for improvements does not need to be discrete but can be continuous over a range as specified by the purchaser. In addition, rather than specifying the required improvement in each quality variable, the buyer may specify the improvement desired in Operating Effectiveness and allow vendors to determine the most cost-effective means of quality improvement (in system performance, system availability, or system durability).

CONCLUSION

Systems acquisition decisions typically require a great deal of forethought and planning to be successful. Quality factors are particularly difficult to incorporate into the acquisition process in a consistent and unambiguous fashion. The approach introduced in this paper suggests the development and application of an analytical model for those sizeable acquisitions where quality factors are likely to be important in making the most cost-effective decision. As developed and illustrated, the approach proposed offers the following key advantages:

- First, it establishes a base-level or minimum requirement of Operating Effectiveness defined by the user.

- Second, the approach explicitly recognizes that potentially there are a number of system alternatives that could provide the required Operating Effectiveness. By quantifying levels of improvement to be incentivized, explicit recognition is given to the integration of system performance, system durability, and system reliability and serviceability (via the system availability parameter). Clearly, neither the most sophisticated or the lowest priced system may represent the most cost-effective decision.

- Third, while not emphasized here, the methodology focuses on minimizing discounted life-cycle costs, not acquisition price as the relevant cost parameter.

- Fourth, the integrated approach to system quality, combined with selective incentives, shifts the suppliers' emphasis away from minimally meeting requirements at lowest acquisition cost to innovation and to systems that optimize Operating Effectiveness, albeit within a defined range. Therefore, by specifying both a floor requirement and a ceiling on price, the supplier must be creative to provide the highest attainable Operating Effectiveness.

- Fifth, the concept provides the buyer a workable vehicle to bring together selected quality dimen-

sions in the decision process in a cohesive and consistent manner that properly recognizes the inherent trade-off possibilities.

In closing, successful application of the approach advocated in this paper hinges on several important considerations. First, the method assumes that an acquisition manager can accurately identify both the minimum level of Operating Effectiveness necessary and the value of improvements to that level. Second, it is assumed that the information provided by suppliers regarding their ability to meet or exceed these specifications can be relied upon. Finally, recognizing the potential for unrealistic projections, nothing can replace the experience and professional knowledge of the buyer. The approach being proposed is simply a tool that would permit objective data analysis which then must be tempered by the buyer's professional judgment. Clearly, use of such an analytical model does not relieve acquisition managers or buyers of their responsibilities to make professional evaluations of system and vendor alternatives.

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ATT ENTERS THE '90's

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ABSTRACT

This paper is a case study of how a Government agency successfully incorporated Total Quality Management into a research and development (R&D) contract with a small business.

The Naval Weapons Center (NWC), China Lake, Calif., had been doing business with a small business called Air Turbine Technology, Inc. (ATT) since 1985. The company developed and improved turboalternators for tactical missiles. For the first several years, things went smoothly, although delivery of the alternators was usually very late.

However, times change. The focus at NWC shifted from hardware to technology and timely delivery was important. We no longer were satisfied with just a piece of hardware delivered months after it was due. ATT did not—or could not—keep up with the changes. The Navy wanted to contract with ATT, but could not get a satisfactory proposal from them.

Too frequently in Government contracting there are three warring factions: the end user, procurement personnel, and the contractor. With ATT the situation had degenerated to the point where at least the Government and the Contractor were at odds.

When ATT had a change in ownership and management, NWC decided to use Total Quality Management (TQM) techniques to remedy the difficulties. This paper tells the story of the events that finally turned the problems around.

NWC invited the contractor to attend a TQM workshop at China Lake. Principles such as flow charting, cause and effect diagrams, design of experiments and allowing all levels of workers to participate were introduced. Procurement, the end user, and the contractor worked together to build the contract, and using TQM techniques, they wrote the Statement of Work, decided on the deliverables, and decided how the contract would be administered. The parties started as adversaries and finished as a team.

The Contractor returned to his facility and used the data developed at the workshop to rewrite his proposal. ATT's new proposal was excellent. It has been partially funded. The proposal received a positive audit report from the Defense Contract Audit Agency. The proposal has an excellent chance of becoming a successful contract.

INTRODUCTION

During the 1980s many organizations in the United States drastically changed their way of doing business by incorporating the principles of TQM into their management style. NWC is one of these organizations. TQM is a concept of management that empowers the people. It uses input from all levels of an organization to encourage constant improvement. It was initially used to improve the quality of mass-produced products. This case study examines how NWC used TQM concepts in a R&D contract with a troubled small business.

ATT is a small business located in Boca Raton, Fla., founded in August 1978. ATT manufactures hand-held tools such as grinders, high-speed routers, and drill presses. Their customers range from mold makers and circuit board manufacturers to water ski manufacturers and the aerospace industry. They enjoy a reputation for producing quality products.

Their approach to management was very traditional. The structure of the organization was the typical American pyramid. The management style was distinctly patriarchal. The Chief Executive Officer (CEO) made all decisions, often without enough input from those actually involved in the work. Any problem in the factory had to go up the chain of command. This was time consuming and important factors frequently never reached the top. Although the company was founded as recently as 1978, the CEO and most of the technical personnel had been in the business for many years. Several were close to retirement.

ATT and NWC started doing business together in 1985 when ATT was awarded a Small Business Innovation Research (SBIR) contract.

The SBIR program is mandated by Public Law (PL 97-219 and PL 99-443). It is a program designed to encourage small businesses with strong R&D capabilities to contract with the Government. A minimum of once a year the Department of Defense (DOD) publishes a list of research topics that would expand the technology base. Small businesses are encouraged to submit technical and cost proposals for contracts to solve these problems.

The SBIR program consists of three phases. Phase I contracts are usually for feasibility studies of six months duration. The legislative history of the program clearly envisioned that the Phase I awards would be in the neighborhood of $50,000.

Phase II awards depend on the results of Phase I and the technical merit of the small business's Phase II proposal subject to the availability of funds. Phase II is the principal R&D effort and is expected to produce a well-defined deliverable product or process. It is typically a two-year effort for about $500,000.

Under Phase III, the contractor pursues or develops commercial applications of the effort using non-federal funds. (However, federal agencies may award Phase III contracts for products or processes that meet mission needs using non-SBIR funds.)

ATT successfully completed the first two phases. However, delivery was extremely late and ATT probably lost money on the efforts.

At this time, both the contractor and the Government technical personnel involved were primarily interested in hardware. Both had traditional approaches to work and management. The Technical Monitor and the ATT principals had a good working relationship although some of the Technical Monitor's subordinates were somewhat less entranced with ATT's performance since the company's late delivery greatly impacted the schedule of the overall project.

The same technical groups that had previously worked with ATT published a topic in the 1987 SBIR solicitation document for development of a high-temperature, high-speed turboalternator for use in tactical missiles. On January 21, 1988, NWC awarded ATT a Phase I contract for this topic.

The period of performance of ATT's Phase I contract was six months beginning January 21, 1988 and ending July 20, 1988. Deliverables included a final report and a prototype high-temperature turboalternator.

ATT failed to meet its July 1988 delivery date. The Technical Monitor was not unhappy with

ATT's progress. He felt the company had generated enthusiasm with suppliers, and both ATT and the suppliers were putting their own money into the project. The focus was on the hardware.

In November 1988, the period of performance was reinstated and a new delivery date negotiated. Rationale for removing the Contractor from delinquent status stated "...we are getting more than we asked for." The new delivery date for the turbine wheel was January 1, 1989. Again, ATT failed to meet the delivery date. Again, we negotiated a new delivery date, February 1, 1989.

The turbine was finally shipped February 3, 1989. A six-month effort had taken more than a year. ATT's final report and Phase II proposal for almost $500,000 followed shortly thereafter. The contract was finally completed.

In early 1989, the Technical Monitor retired and was eventually replaced by John France. Unlike his predecessor, John found working with ATT a problem. ATT's unreliable delivery affected John's work since the effort was part of a larger project. Not knowing when ATT would deliver seriously impacted John's schedule. The data was inadequate and the Phase II proposal was almost incomprehensible. NWC had no clear picture of what ATT planned to do for slightly under $500,000. Also, it was rumored that ATT was in financial trouble.

We now had a contractor in trouble and one that was a risk. On the other hand, the ATT concept had potential and the Government needed the technology. We finally decided to give ATT a four-month "bridge" modification on its Phase I effort.

At its discretion, the Government may negotiate a four-month extension to the Phase I SBIR contract. Such modification is usually issued to provide continuity to the effort while the Phase II is being evaluated and negotiated. The work is part of the Phase II effort and the cost of the modification is deducted from the Phase II proposal.

The Contractor agreed to the "bridge" effort. We negotiated a Statement of Work (SOW) for the four months, carving it out of the SOW on ATT's Phase II proposal. The modification was signed June 29, 1989. The period of performance for the bridge effort ended October 28, 1989. Deliverables included progress reports, a final report, and a prototype turboalternator.

The contract was structured to allow for interim payments for progress reports and a larger payment after acceptance of the final report. The prototype was not separately priced.

During negotiations, we stressed we wanted to be kept informed of progress on the contract. Non-contractual suggestions included using a software program to track the effort and giving us weekly informal progress reports. We also stressed we were more interested in the technology than the hardware.

During the next four months, we began to hear more and more about ATT's financial difficulties. ATT failed to keep us informed, but this was not in the contract. We did receive monthly progress reports, which were marginally acceptable.

The bridge modification was essentially a replay of the Phase I contract. ATT failed to deliver on October 18, 1989. The contractor claimed the effort was 90% complete.

On November 7, 1989, the Government received a "final report" along with an invoice. The Contractor maintained that the hardware was not separately priced, therefore payment should be made for the final report without delivering the hardware. NWC frequently awards R&D contracts with hardware deliverables not separately priced. Our attorney agreed with us that ATT's interpretation of the contract was not valid.

Meanwhile, John read the final report. It was grossly inadequate. It consisted of 4 inches of raw data with no analysis, no conclusions, and no recommendations.

November consisted of a series of telephone calls, all a triumph of non-communication. The CEO and others at ATT either didn't or wouldn't hear what we were trying to tell them. We were having serious communication problems.

On December 1, 1989, we called the contractor and told them flatly we were not going to pay for what had been delivered. We understood they were having financial difficulties, but (1) the contract clearly called for a hardware deliv-erable and (2) the "final report" was unsat-isfactory. The taxpayers apparently were getting nothing for their money.

On the advice of our attorney and the Head of the Small Business Program Office, we decided to send ATT a letter asking them to show cause why we shouldn't terminate them for default.

The letter was sent out certified mail on December 7, 1989. The letter included a list of deficiencies in the final report. We also asked DCASMA Orlando to send an Industrial Specialist to the plant to find out what was going on and to find out if the hardware really existed.

After receiving working drawings and photographs of the parts of the turboalternator, we modified the contract to give the Contractor some financial relief and negotiated a January 21, 1990, delivery date.

January 21, 1990, came and went without delivery. An Industrial Specialist with DCASMA Orlando visited ATT's plant on January 29. He reported all the parts were in house, assembly fixtures were to be completed January 30. He said final assembly should be completed by February 1. Testing would start February 1 and continue through February 7. The forecasted shipping date was February 9, 1990.

The Industrial Specialist also said the company was operating with a skeleton crew. Their building was up for sale and the company planned to move to other quarters nearby. He went on to say that ATT claimed a New York firm was interested in investing in the company.

We decided not to negotiate a new delivery date and to leave the contract in delinquent status.

ATT shipped the prototype on February 10, 1990, more than four months late. John accepted it on February 16. The final report was unsatisfactory on the first submittal. After several iterations, it was minimally acceptable and was approved on May 11, 1990, seven months after it was due. The bridge contract was complete.

THE PROBLEMS

We then had to contend with ATT's new Phase II proposal, which we received in May. Despite the problems we encountered, NWC was interested in the technology ATT proposed. From their proposal, the following problems were evident:

- ATT did not understand Government contracting. They did not know what an SOW was.
- ATT did not know how to estimate a job or to plan for its completion. Realistically, they could not do the work they outlined for the amount they proposed.
- ATT did not understand that NWC was more interested in technology than in actual hardware. We want to know what didn't work and why, as well as what did work and why.
- ATT didn't understand the purpose or content needed for progress and technical reports.

In addition, ATT's management style hampered the process. Decision-making power was in the hands of one person, the CEO. He took all responsibility for the project. All problems and changes had to go up the chain of command and back down for implementation. Frequently, important factors were lost in the process.

WHAT WE DID

During the period of performance of the "bridge" modifications, NWC, like many organizations in the United States, had

embraced the principles of TQM. The Head of the Procurement Department was one of TQM's most ardent advocates. Our Department had become a model for using TQM principles to improve customer service and the work environment. NWC, using TQM, had made great strides in doing the same. For instance, NWC had flattened the organizational structure, deleting barriers to change and improvements. There had been a shift in the way NWC looked at running an organization.

On June 8, 1990, John called a meeting to discuss the problems in contracting with ATT. He brought together a group of NWC employees with all sorts of expertise to help solve our problems with ATT, including a member of the Organizational Change Group, a team that helped other groups at NWC implement TQM techniques. John opened the meeting by saying he was interested in another contract with ATT, but not on the same terms as before. He wanted to build TQM into the contract, to make it a contract requirement. We had talked about ways to use TQM in contracts, but there were no known precedents. He went on to say that an investor had bought controlling interest in ATT. There had been an influx of money and, hopefully, a different managerial outlook, one open to change. ATT now had eight employees.

This was the first of several planning meetings. We eventually invited ATT to a TQM workshop, held at NWC, asking to have as many ATT people involved in the effort as possible attend.

ATT agreed to attend the workshop, which we scheduled for July 11 and 12. The ATT personnel attending included the new President, the former CEO, and almost all of the company's employees (their buyer, business manager, model maker, and engineers). Government attendees, in addition to John and me, included representatives from Procurement, a representative from the Small Business Program Office, and several engineers who worked with John, including his supervisor. A staff member from the Organizational Change Group facilitated the workshop.

Everyone's apprehension over what was about to happen came through when they answered the opening question, "How are you feeling about this workshop?" Some were cautious. Others were downright skeptical. It was quickly apparent that TQM was a new concept to the ATT old hands. Several of the newer people, including the new President, had used TQM methods before and were familiar with the concepts.

We spent most of the first day learning about TQM concepts and techniques. We learned about Pareto diagrams and flow charts and about the design of experiments. We described the elements that achieve the perfect hamburger using Isikawa's cause-and-effect diagram. We learned about the idea of improving processes and reducing the need for inspections, empowering employees at the lowest organizational levels to have input into quality and process improvements. By the end of the day, we were no longer adversaries and more than acquaintances.

On the second day, we started to work on the Phase II proposal. We realized none of the examples given in the TQM texts could be even remotely correlated to our situation. They outlined companies that mass produce products, which is quite different from Government R&D contracting. We were apprehensive about how the principles would apply to a Government contract.

We broke up into three groups to flow chart the process. My group worked on flow charting the contracting process. We found this technique worked well since the process is well-defined by the regulations.

Another team's topic was State-of-the-Art — Determine Improvement. The process seemed to work well for this topic. The group produced four or five pages of flow charts, and the technical people seemed pleased with their presentation.

The third group's topic was the Statement of Work for the contract, what the Contractor would perform to after award. The group consisted mostly of technical folk. This group caught on to the flow charting technique

quickly. Even John's supervisor, who had been so skeptical the first day, participated enthusiastically. Their presentation was by far the most productive and exciting. We had been apprehensive about TQM's applicability to R&D contracting. This group's work resulted in a very cogent first draft of the SOW. They didn't have to force-fit any thing.

The final debrief was a celebration. We did it! In the process, we became a team; the contractor, the technical community, and procurement. I had always felt contracting worked best when the technical people, the contractor, and procurement personnel worked together to make the contract work. The adversarial relationship we previously had with ATT was contrary to my own contracting philosophy. But, the communications problems we had with ATT had seemed unsurmountable. Our workshop had established teamwork using the TQM process.

THE RESULTS

The people from ATT returned to Boca Raton to revise their proposal, which arrived on September 15, 1990. It was excellent, one of the best Contractor proposals we have seen.

The narrative for the SOW was a page and a half long (see Appendix A). It clearly and concisely described the three tasks to be accomplished. The rest of the technical proposal consisted of flow charts describing the process for accomplishing these tasks and the schedule for this accomplishment. Appendix B shows the flow charts for Tasks I and II. Other accomplishments included:

- Reasonable milestones
- Pertinent and timely reports
- Supportable and realistic cost proposal

ATT's proposal enhanced the Government's ability to obtain funds. Tasks I and II have been funded. The proposal received a positive audit report from the Defense Contract Audit Agency. It has an excellent chance of becoming a successful contract. And ATT is experiencing better success in its commercial business. They have incorporated TQM into all phases of the company's work, including manufacture and design of its high-tech tool line.

CONCLUSIONS

For the first time at NWC, we successfully incorporated TQM techniques into a Government contract. This paper is the story of how the effort got into trouble and how TQM was used to solve the problems. We acted within the regulations. Admittedly, this was accomplished on a SBIR contract where the rules are looser.

There are other types of contracts where the techniques can be used. TQM techniques could also be used for Broad Agency Announcements (BAA), another type of contract where the Contractor proposes solutions to an area of R&D interest. What frequently happens on BAA's is the Contractor submits a long, complex proposal that provides the Government with a shopping list of solutions to the problem. The Government then negotiates for portions of the proposal. Instead, the Contractor could submit approaches to solving the problem. If the Government found an approach interesting, they could work out the details of the SOW together using TQM techniques, resulting in a contract that would better satisfy the needs of the Government.

There is no reason to not use TQM techniques in sole-source situations. The Government frequently doesn't know exactly what it wants and there is a tendency to award the contract then fix it later. Or, we write poor specifications. The Government has to learn that the Contractor has something to contribute, especially when it is the sole-source contractor. If we took TQM's long-short approach and spent time in the beginning with the Contractor to write a well-defined, cogent, achievable SOW and/or specification, we would probably save time in the long run. We would end up with a better product, probably delivered in a more timely manner.

It is not now possible to use these techniques in the competitive environment, except in the pre-solicitation phase. However, we are using flow charting to help the technical codes write better competitive SOWs. The discipline of

flow charting yields a clearer picture of tasks. It helps the Contractor propose more realistically and helps the Government perform better technical and cost evaluations. On several recent requirements, flow charting resulted in much improved SOWs.

The ideal would be to find a legal way to incorporate TQM techniques with Contractor participation in a competitive situation. Or to change the regulations to allow Contractor participation in developing a requirement.

Appendix A
STATEMENT OF WORK

B: PROGRAM PLAN

This Program is divided into 3 major tasks which are summarized below:

TASK I

Task I of this program is that part of the program which justifies and presents a preliminary design. This task begins with the start of a literature search which will help define the state of the art and supply data for the parametric analysis.

The parametric analysis, will present the effect on performance of different types of turbines and alternators and their major design requirements. These data will be examined and a set of requirements will be generated which will be both realistic and satisfy the Naval Weapons System requirements.

The above effort, will lead into a trade study which will look at different turbine and alternator types with a common set of requirements. These trade studies will result in an evaluation, of each turbine and alternator type studied, and will compare the overall size, weight, cost, schedule and risk for each item studied. As a result of this effort, a preliminary design will be identified and agreed upon. This will complete Task I of the Program.

TASK II

Task II of this program is that part of the program which justifies and presents a prototype design. It will begin with preparation of drawings and specifications which will define the engineering requirements for the components and assemblies. These data will flow into the procurement area where make or buy, lead time analysis, request for proposals/quotes will be generated. When proposals and quotes are received, they will be evaluated and vendors will be selected.

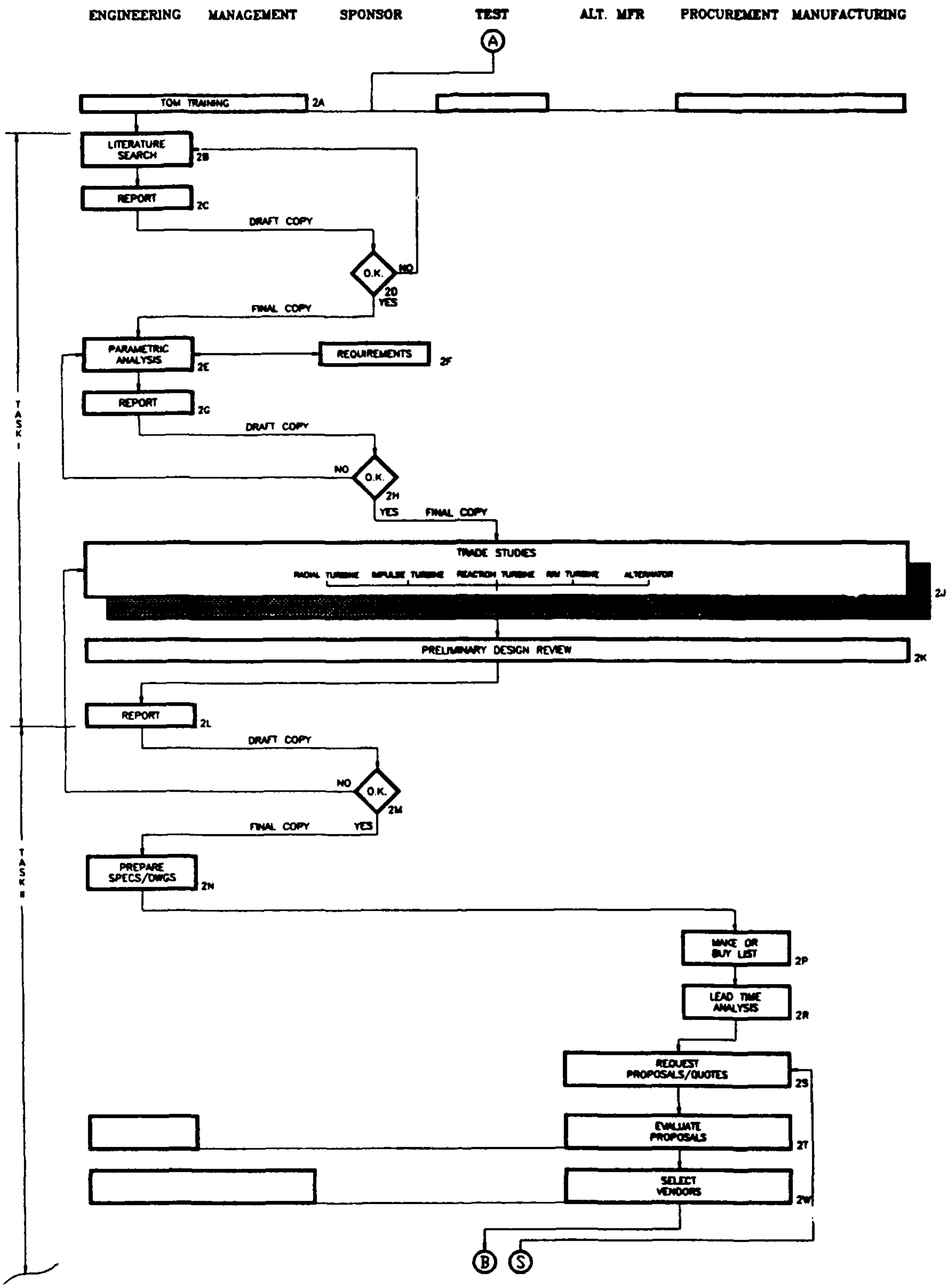
Certain component parameters will either need to be verified or determined thru component test. These data will then be used in the detail design of the prototype unit.

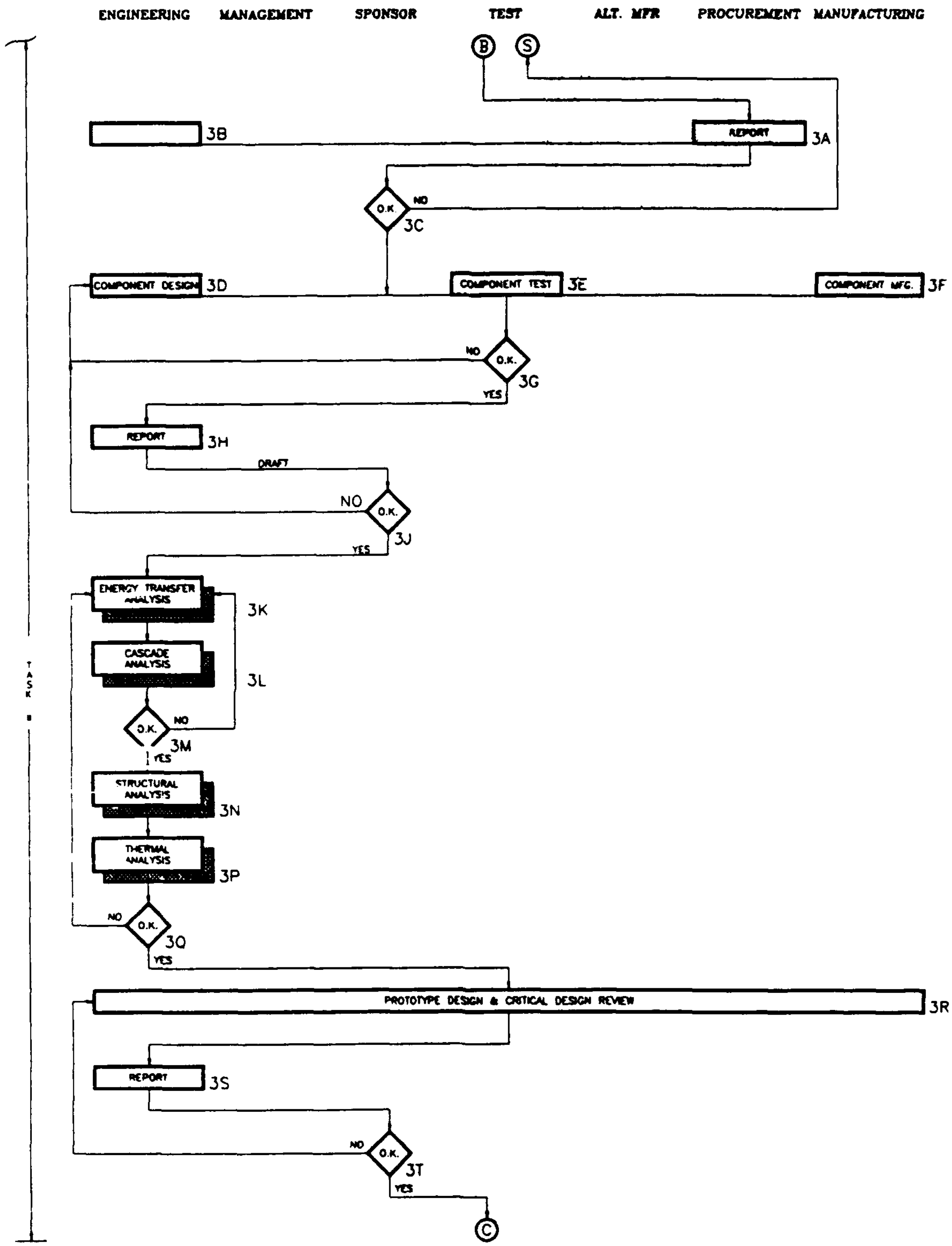
This effort will result in a prototype design that will be presented in the critical design review. Approval of the prototype design, signals the completion of task II of the program.

TASK III

Task III of this program is that part of the program that builds and tests the prototype unit. It begins with a detail review and understanding of all drawings and specifications. This will be followed up with the generation of shop and quality control procedures for all detail parts and assemblies. The results of the above effort will culminate in the building of the prototype unit. After a design of experiments analysis, a test program will be defined and implemented. The data from this test program will be analyzed and if necessary, the prototype design will be modified and retested. This effort will be reflected in the final design review and the final report which completes this program.

Appendix B
EXAMPLE OF FLOW CHART BY AIR TURBINE TECHNOLOGY





ENGINEERING
MANAGEMENT
SPONSOR
TEST
ALT. MFR
PROCUREMENT
MANUFACTURING
B
S
3B
REPORT
3A
O.K.
NO
3C
COMPONENT DESIGN
3D
COMPONENT TEST
3E
COMPONENT MFG.
3F
NO
O.K.
3G
YES
REPORT
3H
DRAFT
NO
O.K.
3J
YES
ENERGY TRANSFER ANALYSIS
3K
CASCADE ANALYSIS
3L
O.K.
NO
3M
YES
STRUCTURAL ANALYSIS
3N
THERMAL ANALYSIS
3P
NO
O.K.
3Q
YES
PROTOTYPE DESIGN & CRITICAL DESIGN REVIEW
3R
REPORT
3S
NO
O.K.
3T
YES
C
TASK

CONTRACTING IMPEDIMENTS TO CONTRACTOR PRODUCTIVITY AND QUALITY IMPROVEMENTS

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ABSTRACT

This paper examines the impact of defense contracting policies and practices on defense contractors' efforts to improve the productivity and quality of their operations. The Just-In-Time (JIT) philosophy has been used by numerous Japanese and U.S. companies to achieve impressive productivity and quality improvements, especially in the electronic and automotive industries. A limited number of those companies have also applied JIT principles into their defense operations. However, defense contractors face a considerable amount of control over their operations which may make it difficult to make the significant and innovative changes to the production and purchasing functions that JIT mandates.

In order to determine the impact of the defense contracting environment on defense contractor productivity and quality improvement initiatives, the JIT efforts of six defense electronics producers were examined through on-site visits and interviews. Structured interviews were conducted with 42 production managers and 27 purchasing managers associated with JIT projects. The respondents rated the impact of 19 contracting practices on their JIT efforts. They also identified the specific contracting problem areas, the JIT production and purchasing activities most seriously impacted, and changes the government could initiate that would be most supportive of their JIT efforts.

This paper presents research findings that identify potential government obstacles to JIT implementation and suggests opportunities for government Total Quality Management (TQM) initiatives that would support contractors' JIT efforts.

INTRODUCTION

The incredible success of Japanese producers in achieving unparalleled levels of productivity and quality, as well as penetrating and dominating many U.S. markets, have forced U.S. companies to adopt new management philosophies to improve the productivity and quality of their operations. Several related approaches have emerged which have continuous improvement as their basic foundation, a process the Japanese call Kaizen.[1] Total Quality Control (TQC), also called Total Quality Management (TQM), focuses attention on process improvement, especially in terms of product and process quality. The Just-In-Time (JIT) approach focuses on the elimination of all waste in a system to improve the quality, timing, and efficiency of the flow of materials.[2] Another approach, called the Theory of Constraints (TOC), improves the flow of materials by identifying and managing

*The views expressed in this paper are those of the author and not the Department of Defense nor the United States Air Force.

bottlenecks or constraints that limit the throughput of an organization.[3] These different, though highly complementary approaches, all require an organizational culture that promote continuous improvement as a way of life.

Continuous improvement requires continuous change, which is a challenge for any manager. It requires an organizational culture that accepts and promotes change as an acceptable, even desireable, condition. In addition to the challenges most organizations face in establishing such a climate, defense contractors encounter extensive government involvement in their internal operations through such mechanisms as contractual requirements and contracting policies, laws, regulations, and oversight activities. While the purpose of such controls is to protect the government's interests, numerous studies, academic and otherwise, have concluded such controls are frequently overly restrictive and counterproductive.[4]

This paper focuses on impediments that defense contractors may encounter in their productivity and quality improvement initiatives. First it briefly addresses general impediments that any organization faces in trying to develop an organizational culture that fosters continuous improvement. It then examines specific contracting oriented problems that can impede contractors' continuous improvement efforts.

GENERAL IMPEDIMENTS

Prior to discussing problem areas unique to the defense contracting environment, it is useful to consider general problems organizations face when embarking on the road to continuous improvement.

One of the first obstacles that must be overcome is simply that of inertia. In the physical world, inertia is the tendency of objects to remain in a state of rest or to continue in the same direction at the same speed if already in motion, unless sufficient force acts upon it to force a change. Organizations also behave similarly. Many U.S. companies have pursued JIT implementation only when their economic survival was threatened by foreign competition. Otherwise, the tendency is to continue with the status quo. It is difficult to institute a cultural change without a strong motivational experience to support and sustain it.

Given that inertia is overcome and an initial commitment to continuous improvement is achieved, whether proactively or reactively, considerable resistance may still exist. In the physical world, an appropriate amount of force is required to overcome inertia. Newton's second law of motion suggests that the greater the mass of the object, the greater is the force required to achieve the desired change. People and organizations resist change when it is forced upon them. Goldratt suggests a chain of reactions occurs: 1) any improvement requires change, 2) people tend to perceive change as a threat to their security, 3) such a threat prompts emotional resistance which 4) can only be overcome by a stronger emotion.[5] He further suggests that the only way to make meaningful, enduring change is to have the workers solve the problem, come up with the desired change, and be committed to implementing it.[6]

Once inertia and resistance to change is

overcome, constraints must be dealt with. Physical limitations can limit the amount of improvement that can be made unless solved through better management or technical improvements. Some constraints are matters of policy and serve to limit creative solutions to problems. These constraints are those we impose on ourselves or that others impose upon us. They may be real or perceived and are dangerous because they contribute to inertia. JIT, TQM, and TOC all focus to some degree on finding ways to overcome such constraints, especially that of challenging policies and assumptions. As previously noted, defense contractors must comply with a host of government contracting policies and controls. This research was primarily concerned with identifying defense contracting policy constraints that might impede contractors' productivity and quality improvement efforts. In order to do this, defense contractors' JIT implementation efforts were examined and the impact of government contracting policies and practices on those efforts were evaluated.

RESEARCH METHODOLOGY

Six defense contractors participated in the research. A total of 29 JIT projects were examined at eleven separate plant sites, spread over four states. All involved complex electronics products using similar technologies and processes. In this way, variations in responses due to different production and purchasing environments were minimized as much as possible.

Structured interviews were conducted with 42 production and 27 purchasing personnel selected by the contractors as being their most knowledgeable and experienced JIT experts. Each assessed the impact of 19 government controls on their overall JIT effort using seven-point Likert scales plus each individual's own supporting explanations. This served to compare evaluations while also providing insight into the details of each contractor's JIT experience. In addition, everyone interviewed was asked to identify the changes the government could make that would best support their continuous improvement efforts. Before discussing the impediments, a brief overview of the contractors' JIT efforts will be presented.

OVERVIEW OF JIT EFFORT

JIT seeks to perfect the flow of materials so high quality products can be produced at a low cost. In addition to a commitment to continuous process improvement, JIT seeks to reduce costs by eliminating all waste in a system. Waste includes anything that adds costs or time to production without adding value, such as producing too much, waiting for missing parts at assembly, unnecessary transportation, wasted processing or motion, inventories, or producing defective products.[7] Waste reduction efforts are applied internally, into the company's own operations as well as externally into supplier and distribution operations. The contractors in this study primarily focused their efforts on establishing JIT production lines and secondarily on the purchasing systems that supported those lines.

JIT Production

JIT requires a work climate that carefully cultivates and nurtures its workers, giving them authority to find and eliminate

waste in their own work areas. The contractors' efforts were quite extensive in this area. They used small group improvement activities to encourage workers to improve the processes for which they were responsible. They also cross trained their workers to achieve the flexibility to move workers to wherever most needed.

Contractors organized their facilities to improve the flow of materials in terms of distance and time. Production facilities were highly focused factories in terms of related products and technologies. Production equipment and resources also were dedicated to specific products, eliminating to a large extent competition for shared resources. These resources were also located very close to each other to minimize the distance material traveled. In some cases contractors organized equipment into group technology cells to achieve many of the benefits of a dedicated production line for closely related products. These JIT activities greatly reduced the length of the flow of materials and also served to reduce the manufacturing cycle time.

The contractors also undertook several initiatives to speed up and smooth out the material flow. All JIT projects undertook some reduction in lot sizes and work-in-process inventories which served to further reduce manufacturing cycle time. They also converted from monthly production schedules to daily or weekly schedules to achieve a consistent and smooth pattern of production. Set-up time reduction activities were limited because dedicated production lines required no chagnes in setups. Quite a number of contractors converted to a pull production control system where production takes place only when the next operation signals that the parts are needed. These activities greatly speeded up and smoothed out the material flows as well as eliminating overproduction.

Contractors worked to achieve continuous flows by eliminating disruptions associated with quality or equipment problems. Primary efforts to achieve Total Quality Control included making workers responsible for quality and stopping the production line when defects occurred. Contractors had also begun to use Statistical Process Control (SPC) but were just in the early stages. Efforts to eliminate equipment breakdowns included preventive maintenance activities and to a lesser extent operator maintenance and equipment/process improvement. Contractors were limited in their ability to make the process improvements by government controls over specifications and engineering changes.

While most of the JIT production activities were quite successfully applied by defense contractors, there were some problem areas in obtaining government support. Contractors had mixed success in negotiating contract schedules that permit frequent shipments of small lots. Most had to rely on contract provisions that permitted early and partial deliveries. They also were not successful in reducing paperwork and administrative requirements. In fact, many reported that JIT production actually increased the amount of paperwork the government required due to the small lot sizes. Finally, contractors did not choose to challenge government constraints, but instead implemented JIT totally within government requirements.

JIT Purchasing

JIT promotes the development of long-term relationships with suppliers that are thoroughly dependable in terms of quality and delivery. Contractors worked extensively to develop supplier partnerships, especially in regards to helping suppliers incorporate TQC principles to achieve high levels of quality. However, contractors were not very active in helping suppliers incorporate JIT into their own operations.

Contractors implemented some JIT purchasing activities in spite of government competition and multiple sourcing requirements. Contractors reduced their supplier base to include only their best suppliers and developed supplier partnerships by working closely with sole sources, justifying the use of single sourcing, or (more commonly) awarding competitive contracts based on quality, delivery requirements, and cost. Contractors also awarded long-term contracts or contracts with options, to develop quasi-supplier partnerships while still staying within the bounds of competition and multiple sourcing requirements.

Contractors were not very successful in developing local suppliers and achieving JIT deliveries, mostly due to the nature of their suppliers. Highly specialized electronics components were not conducive to local sources and low volumes made it difficult to motivate suppliers to make JIT deliveries. Further, government directed sources were frequently not cooperative.

Contractors reported heavy restrictions to streamlining inspection and receiving requirements, primarily due to quality and documentation requirements. However, they were able to minimize those inspection and receiving requirements to a moderate extent, relying for the most part on source inspections. As in the case with JIT Production, contractors were not able to reduce administrative and documentation requirements.

While contractors experienced overall freedom to engage in most JIT activities, especially in the production area, that does not mean that there are no government obstacles or limitations. Indeed, many contractors purposefully implemented their JIT activities in ways that would conform to existing government contracting requirements. Since contractors' responses suggest that are relatively unwilling to directly challenge government constraints, contracting policies and controls may impede to some degree the extent that JIT/TQC can be implemented by defense industries.

GOVERNMENT CONTROLS

Defense contractors assessed the impact of 19 contracting policies and practices on their JIT production and purchasing efforts. Each respondent evaluated the impact of each control using a seven point scale with 1 being a strong positive effect and a 7 being a strong negative effect on their JIT efforts. Tables 1 and 2 summarize their ratings in the production and purchasing areas respectively. The policies are ranked by mean scores, with higher scores indicating a more negative effect on JIT efforts. To simplify discussion, the practices will be grouped into five categories:

1) engineering and specifications, 2) internal controls, 3) use of government resources, 4) contract negotiation issues, and 5) material and sourcing policies.

Engineering/Specification Controls

The government controls product design and production processes through the use of military standards, direct control over specifications,and through engineering change procedures, including its value engineering program. Mil-Standards were judged by 71 percent of production respondents to adversely impact their JIT efforts. The major problems centered around quality requirements and inspection criteria mandating separate in-process inspections based on lot sampling plans and the use of visual inspection criteria which reject soldering for cosmetic reasons and require repairs which lead to lower reliability. Contractors also complained that the mil-standards are restrictive and difficult to change, holding contractors to outdated technology and methods. This strikes at the heart of JIT, which strives for continual improvement. The purchasing assessments were mixed, with positive factors including standardization and improved quality and negative ratings associated with increased production lead time, limited availability of suppliers, and interpretation problems.

Government control over specifications and associated engineering change procedures were the two most negatively rated controls for both production and purchasing. The major problem appears to be the limited flexibility contractors have to make changes and solve problems that JIT and SPC identify. Many respondents stressed that the procedures to make changes were so time consuming and costly that they tended to discourage all but the most urgently needed changes or those that have a very large and immediate payback. This is a serious concern in that JIT stresses continuous improvement which thrives on change, yet the change process is so cumbersome that making changes causes its own set of disruptions.

The Value Engineering program should have been a positive tool for both production and purchasing since it provides a vehicle for making cost effective changes and allows the contractor to share in the cost savings. However, in both cases, the program was judged to have little or no impact because the time and effort required for approval discourage its use.

Tight controls over specifications and the difficulty with which changes are made negatively impact JIT implementation in both the production and purchasing areas. In a similar vein, the government's control over contractors' internal operations can also be a problem for JIT.

Internal Controls

The government exerts controls over a contractor's internal operations in several ways. Through contractual requirements, mil-standards, and laws, enforced by inspectors and auditors, contractors must establish quality, accounting, and other systems that meet government requirements. The most serious problem involves controls over quality.

Contractual quality requirements were generally viewed as a negative factor for JIT production and purchasing, with 69

percent of the production and 55 percent of the purchasing responses being negative. Contractual quality requirements and JIT have congruent goals to improve quality. The conflict appears to be in the means to achieve that end. In the production area, contractors want to replace formal inspections with certified operators and statistical process control but feel constrained from doing so by requirements for separate government and company inspectors. Inspection points, especially if lot sampling is used, work against JIT's objectives of achieving continuous and linear flows of material. Purchasers complain that the requirements add costs and cause interpretation problems, without improving the quality of purchased parts. In both areas, respondents suggested contract quality requirements limited the extent to which they could achieve total quality control, especially in terms of eliminating centralized inspection points and shifting the responsibility for quality to production workers or suppliers.

The enforcer of the contract quality requirements is the Quality Assurance Representative (QAR). The responses varied considerably with over half of production and purchasing respondents saying the QAR either had no effect or contributed positively. Those who had negative experiences gave a wide variety of reasons, the most common being inspection delays and insistence on batch sampling methods. The reported experiences and rationales were so diverse, and even contradictory, that the impact of the QAR on JIT appears to be a function of the individuals involved. The QAR can serve as a resource that minimizes the impact of government quality requirements on JIT or can be an obstacle that magnifies the problem.

The impact of government audits and reviews was more serious for purchasing than production. Nearly half of the purchasing respondents rated it negatively, primarily due to prolonged audits which delay contract award and program start, causing additional workload due to expired quotes and shortened purchasing lead time (because need dates rarely change). Audits also tended to increase documentation requirements and cause people to focus more on the paperwork than getting the job done. On the production side, 38 percent reported negative impacts. Audits were seen as disruptive to throughput because they prompt overly cautious and negative attitudes similar to that described by the purchasing respondents.

The other internal controls examined impacted production and purchasing somewhat differently. A third of the production respondents said Cost Accounting Standards had a negative effect because the standards were complex and outdated, especially in regard to detailed labor tracking requirements which are not conducive to flexible workers whose activities could span a number of different operations and include both direct and indirect activities. CAS was not a major problem in the purchasing area. Government reporting requirements do not appear to be much of a problem for either production or purchasing. In general, these internal controls appear to be nuisance factors. Most of the contractors have found ways to live with them as a cost of doing business.

Use of Government Resources

The government frequently provides government furnished property and progress payments to contractors. The purchasing and production evaluations suggest that use of these resources do not have an adverse impact on JIT. Most respondents judged it to be not applicable or having no impact. On the positive side, it provides the contractor with dedicated equipment. On the negative side, contractors report that its use is severely restricted so that it cannot be efficiently used and is so tightly controlled that contractors cannot improve the equipment. The dedication of resources fits nicely with JIT but limitations on making improvements or having the flexibility to use it to its best advantage inhibits JIT continuous improvement efforts.

Progress payments were generally judged by those interviewed to not impact JIT. Over half the respondents in both areas scored it as not applicable or not having any effect on JIT. Nearly 30 percent of the purchasing respondents saw some benefit in having the cash flow to get materials flowing and having the government finance inventories and early buys. Those views were echoed by about 12 percent of the production respondents. These views, however, appear to be counter to the JIT logic which suggests that inventories clog the material pipeline and hide problems. Only 7 percent of the purchasing interviews and 16 percent of the production interviews indicated a negative impact. Most of the negative assessments suggested progress payments prompt bad inventory decisions and restrictive inventory controls. A statistical analysis comparing the extent of JIT implementation with the use of progress payments found that contractors which used progress payments had significantly lower JIT implementation scores than those that did not. Progress payments may be a two edged sword. They might be able to be used to support JIT activities, yet they can also serve to provide inventory safety nets that inhibit JIT progress.

Contract Negotiation Issues

Four of the contracting practices involve negotiation issues, namely the cost/pricing data, the government's profit policy, contract delivery requirements, and changes/modifications to the contract after contract award.

The requirement to provide cost or pricing data appears to have only a minor negative impact on JIT production. However, a few respondents felt that JIT increased the contractor's risks of a defective pricing claim and audit. Cost savings due to JIT are hard to predict and therefore disclose. If substantial cost savings occur, they feared the customer would charge that the contractor deliberately failed to fully disclose all information available. One respondent believed that JIT cost savings had actually resulted in an audit. While nearly 30 percent of the purchasing respondents gave negative ratings in this area, there was no consensus of opinion as to the actual impact. In fact, since purchasing required cost or pricing data from their suppliers, they were much more tolerant of its use.

Profit policy was expected to have a negative impact on JIT because of the government's tendency to base profit

rates on costs and the possibility of negotiating away a contractor's cost savings on future contracts. A few concurred in that view. However, most rated it as having no impact. A few saw low profit rates and fixed-price-incentive contracts as positive motivators for JIT. The others saw restricted profits as discouraging long-term capital investment/cost-reduction efforts, rewarding inefficiency, and placing the contractor at risk for defective pricing. The respondents recognized the fact that cost reductions resulting from JIT activities might benefit the contractor only for the short term, but felt that those are the rules of the game and that such efforts were required to be competitive and win future contracts.

The contract delivery schedule was expected to have a positive impact on JIT production because of its relative firm demand pattern. A few respondents concurred in that view. A third of the purchasing respondents rating it negatively, all of them citing unrealistic schedules with inadequate purchasing lead time. The only problem on the production side was that the contract schedule occasionally did not match the small lot production pattern that had been established under JIT.

Post-award negotiation activities due to contract changes appeared to have little or no impact on JIT according to most of the respondents. Many actually responded that JIT actually made contract changes easier to handle. Of those that experienced problems in the production area, two major issues emerged, 1) the government's cycle time for issuing modifications to cover changes was excessive and put the contractor at some risk, and 2) engineering changes tended to disrupt production and increase costs. On the purchasing side, contract changes occasionally were disruptive to suppliers and did not provide enough time to effectively deal with the problems.

Overall, the contract negotiation issues discussed here are not problems for JIT implementation. Most respondents were committed to JIT even if the government negotiated away cost savings because it was the prudent business thing to do to remain competitive.

Material and Sourcing Policy

The last area to be examined involves government policy concerning socioeconomic programs, subcontracting, control over sources, and priority of government orders. Subcontracting policy was a problem for both JIT production and purchasing. The others had somewhat mixed responses.

Socioeconomic programs had a slightly negative overall rating for production. However, it does not appear to be too severe of a problem, since 60 percent judged it as having no impact. In the purchasing area, respondents were almost evenly divided between positive, neutral, and negative ratings. The major issues involve the use of small businesses and small and disadvantaged businesses. Some felt positive about using them, suggesting they were willing to provide the kind of service needed for JIT. However, others had negative experiences where they felt forced to use unreliable vendors and unable to develop long-term, efficient buyer-seller relationships. The major concerns focused on vendor related issues, especially in terms of the

supplier's willingness and ability to deliver a quality product on time.

The government's subcontracting policy was found to negatively impact JIT efforts. As would be expected, the most negative impact was in the purchasing area. The comments of both purchasing and production respondents closely paralleled each other, suggesting government policies increase proposal/purchasing cycle time and inhibit development of close supplier relationships. The policies of concern involved government requirements to use multiple sources and competitive bidding. In addition, concerns were expressed about the impact of government purchasing regulations on the quality of incoming parts, specifically that awarding to the low offeror made quality suffer and that using multiple sources caused variation in materials that put their system out of control. Those that had experienced problems felt quite strongly about it with over 20 percent of the production and purchasing responses falling in the highest two categories.

The use of government directed sources or those on a qualified parts list appears to be a greater problem for production than for purchasing. About 30 percent of the production respondents and 25 percent of the purchasing ones experienced trouble with such sources. Most cited problems with qualified parts list suppliers which operate under heavy schedules and cannot, or will not, provide the desired performance in terms of quality and delivery. Several purchasers indicated such lists greatly simplify source selection, as long as the sources are good performers. Apparently, however, some situations arise when the contractor is forced to use a supplier that would ordinarily not be their first choice and this adversely impacts cycle time, costs, and schedule. When asked why they did not work with the problem vendors to make them more compatible with JIT, the response was usually that the volume of parts was so low that the contractor lacked leverage or influence to get the supplier to perform.

On the whole, most of the contracting policies and practices evaluated did not have as serious an impact on JIT production and purchasing efforts as anticipated. The contractors' ratings and explanations suggest that most JIT activities can be accomplished well within the current DoD regulatory environment. However, their assessments also suggest there are changes the government could make to better support contractors' continuous improvement efforts.

CONCLUSIONS

The experience of the six contractors that participated in this study suggest that by and large, contractors have considerable opportunity to improve their production and purchasing operations without trying to challenge government contracting policy constraints. However, their evaluations suggest that there are some policies that may eventually limit the full extent to which JIT production and purchasing can be implemented.

In the production area, government engineering change procedures and controls over specifications, quality requirements, and subcontracting have the potential to seriously constrain continuous improvement efforts. When contractors were asked what changes the government

could make to best support their JIT production efforts, the most common responses (in order of importance) were as follows:

1. Streamline engineering change procedures.
2. Shift from quality inspection to SPC/quality audits.
3. Use performance specifications in lieu of design specs.
4. Make quality requirements conducive to JIT/SPC/TQM.
5. Shift to commercially available parts.
6. Reduce the number and intensity of audits.
7. Relax restrictions on purchasing.
8. Permit the use of certified operators.
9. Reduce documentation requirements.
10. Increase multi-year procurements.

Six of the desired changes deal with specification and quality issues. Contractors would like better government support to make the process, product, and quality changes required to achieve the benefits of JIT.

This suggests several targets of opportunity for TQM initiatives to support defense contractor productivity and quality initiatives. First and foremost, a balance needs to be struck between the controls necessary to safeguard the configuration of our weapon systems and the freedom contractors need to make process and product improvements that would be in the interests of both parties. One way to do that would be to streamline engineering change procedures so changes can be made easier and quicker. This would require an examination of the change process to eliminate non value added activities to reduce the approval cycle time. Another way would be to determine the minimal level of specification control necessary to safeguard DoD interests and to exercise controls only over those critical areas. A combined DoD/Industry TQM initiative would be warranted to solve this problem.

DoD also needs to evaluate its quality assurance program to ensure contractors have the freedom necessary to pursue the limits of Total Quality Control. Some initiatives are already underway. The Defense Contract Management Command has restructured its approach to quality assurance to make the Quality Assurance Representative a problem solver rather than an inspector. Its In-Plant Quality Evaluation (IQUE) Program shifts the focus from inspections and procedures to measuring, controlling, and improving processes. This program should give contractors and the QARs the flexibility to better achieve the Total Quality Control that JIT demands and move away from the inspection mentality. In addition, one of the mid-range goals at the DoD level is to harmonize DoD Directives, Regulations, and Instructions with TQM.[8] Therefore, there is hope on the horizon for elimination of any policy barriers in conflict with JIT and TQM.

Purchasers were also given the opportunity to identify the changes the government could make to support JIT purchasing efforts. Their responses were as follows:

1. Relax competition requirements

and preference for low bidders.

2. Reduce documentation requirements.
3. Reduce audit activity.
4. Use more multi-year procurements.
5. Permit more single sourcing/supplier partnerships.
6. Simplify contracting procedures.
7. Reduce quality/inspection requirements

Their responses indicate a desire to have greater purchasing freedom to make good business decisions. Relaxation of such restrictions was also a high priority for production as well. Many defense contracting organizations have been moving away from a low bid mentality and toward best value contracting, where awards are based on costs and other factors, such as quality and delivery performance. Their efforts have been strengthened by Title VIII, Section 802, of the 1991 Defense Authorization Bill which permits the award of negotiated contracts, without discussions, on the basis of cost and other non-cost or non-price related factors. Thus, as the government continues to pursue commercial style competition, it is likely that contractors will also gain greater freedom to pursue similar efforts. It should be noted that many of the JIT purchasing efforts were quite successful at pursuing long-term partnerships through judicious use of competition combined with multiple year options.

Reduction of documentation requirements and audit activity is another area that would support both JIT production and purchasing efforts. The Defense Contract Audit Agency has a Contractor Risk Assessment Guide (CRAG) program which applies principles of quality assurance to the oversight process. When contractors demonstrate their internal control systems are effective and share the results of that system with the government, then the frequency and intensity of audit activity is diminished. Documentation is still an issue that needs to be addressed by a TQM initiative to assess the value of all documentation and find less costly ways to satisfy the need for audit trails without the burdensome paperwork that currently must be accomplished.

The success with which the contractors were able to implement JIT production, and to a lesser extent, JIT purchasing, suggests they have considerable latitude within the DoD regulatory structure to make productivity and quality improvements. If contractors can overcome inertia and initial resistance to change, a considerable amount of improvement can be made without encountering or challenging significant government policy constraints. However, as JIT implementation efforts mature, it is likely that policy constraints will play a greater and greater role. The JIT experiences of these contractors underscore some critical areas in which DoD could focus TQM initiatives to better support contractors' productivity and quality improvement efforts.

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Table 1

Impact of Government Controls on JIT Production Efforts

Contracting Policy Variable	N/A	Strong Pos 1	2	3	No Effect 4	5	6	Strong Neg 7	Mean	Std Dev	Rank
	RESPONSE FREQUENCY (%) BY RATING								RESPONSE		
Eng. Change Proc.	16.7	2.4	0.0	0.0	9.5	16.7	23.8	31.0	5.80	1.3	1
Specification Controls	19.0	0.0	0.0	2.4	28.6	14.3	21.4	14.3	5.20	1.2	2
MilStandards	2.4	0.0	0.0	9.5	16.7	35.7	26.2	9.5	5.10	1.1	3
Quality Reqts.	0.0	2.4	2.4	2.4	23.8	33.3	21.4	14.3	5.05	1.3	4
Subcontracting Policy	4.8	0.0	0.0	4.8	54.8	14.3	11.9	9.5	4.65	1.1	5
Govt. Specified Sources	33.3	0.0	2.4	0.0	33.3	19.0	9.5	2.4	4.61	1.0	6
Govt. Audits/Reviews	2.4	0.0	0.0	2.4	57.1	26.2	4.8	7.1	4.56	0.9	7
Contract Changes	2.4	0.0	0.0	2.4	66.7	14.3	9.5	4.8	4.46	0.9	8
Cost Accounting Stds.	0.0	2.4	4.8	2.4	54.8	11.9	19.0	4.8	4.45	1.2	9
Socioeconomic Progs.	0.0	0.0	0.0	7.1	61.9	16.7	9.5	4.8	4.43	0.9	10
Cost/Pricing Data	7.2	0.0	0.0	0.0	76.2	4.8	4.8	7.2	4.38	0.9	11
Govt. Property	31.0	0.0	0.0	4.8	38.1	21.4	4.8	0.0	4.38	0.7	12
Govt. QA Rep.	2.4	4.8	4.8	16.7	26.2	28.6	16.7	0.0	4.22	1.3	13
Progress Payments	19.0	0.0	4.8	7.1	52.4	7.1	4.8	4.8	4.18	1.1	14
Profit Policy	0.0	0.0	4.8	7.1	66.7	14.3	4.8	2.4	4.14	0.9	15
Reporting Reqts.	19.0	0.0	0.0	7.1	59.5	11.9	2.4	0.0	4.12	0.6	16
Contract Delivery Sched	0.0	2.4	4.8	9.5	61.9	9.5	11.9	0.0	4.07	1.04	17
Defense Priority System	0.0	0.0	0.0	7.2	85.7	2.4	4.8	0.0	4.05	0.9	18
Value Engineering	28.6	0.0	7.1	4.8	52.4	4.8	2.4	0.0	3.87	0.8	19

Table 2

Impact of Government Controls on JIT Purchasing Efforts

Contracting Policy Variable	RESPONSE FREQUENCY (%) BY RATING								RESPONSE		
	N/A	Strong Pos 1	2	3	No Effect 4	5	6	Strong Neg 7	Mean	Std Dev	Rank
Eng. Change Proc.	11.1	0.0	0.0	0.0	40.7	18.5	22.2	7.4	4.96	1.0	1
Specification Controls	11.1	0.0	3.7	11.1	18.5	25.9	22.2	7.4	4.83	1.3	2
Subcontracting Policy	7.7	0.0	3.8	7.7	34.6	19.2	19.2	7.7	4.71	1.3	3
Govt. Audits/Reviews	3.7	0.0	0.0	3.7	44.4	37.0	7.4	3.7	4.62	0.8	4
Quality Reqts.	0.0	3.7	3.7	7.4	29.6	37.0	7.4	11.1	4.59	1.4	5
Govt. Specified Sources	40.7	0.0	3.7	7.4	22.2	14.8	3.7	7.4	4.50	1.4	6
Mil-Standards	0.0	0.0	3.7	22.2	25.9	25.9	14.8	7.4	4.48	1.3	7
Contract Changes	7.4	0.0	0.0	3.7	59.3	18.5	7.4	3.7	4.44	0.9	8
Reporting Reqts.	11.5	0.0	0.0	3.8	57.7	23.1	0.0	3.8	4.35	0.8	9
Govt. QA Rep.	14.8	3.7	0.0	3.7	48.2	25.9	0.0	3.7	4.26	1.0	10
Socioeconomic Progs.	3.7	3.7	0.0	22.2	37.0	18.5	7.4	7.4	4.23	1.3	11
Cost Accounting Stds.	0.0	0.0	3.7	7.4	59.3	29.6	0.0	0.0	4.15	0.7	12
Govt. Property	44.4	3.7	3.7	0.0	25.9	18.5	3.7	0.0	4.13	1.2	13
Cost/Pricing Data	7.4	0.0	3.7	11.1	63.0	0.0	14.8	0.0	4.12	1.0	14
Profit Policy	0.0	0.0	0.0	3.7	88.9	3.7	0.0	3.7	4.11	0.6	15
Contract Delivery Sched	0.0	11.1	11.1	3.7	40.7	18.5	7.4	7.4	3.96	1.6	16
Defense Priority System	3.7	3.7	3.7	18.5	51.8	11.1	0.0	7.4	3.96	1.6	17
Value Engineering	25.9	0.0	3.7	14.8	48.2	7.4	0.0	0.0	3.80	1.4	18
Progress Payments	25.9	3.7	7.4	18.5	37.0	3.7	3.7	0.0	3.55	1.1	19

MISCELLANEOUS

STATEMENT OF WORK PREPARATION SKILLS: A LOST ART

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ABSTRACT

The Statement of Work (SOW) is one of the most important documents prepared by the government for acquiring weapon systems and services. The SOW is a comprehensive listing of all tasks the contractor is responsible for in meeting contractual requirements. Subsequently, the SOW becomes the basis for performance measurement, scheduling, pricing, and risk identification and reduction. Contractor and government rights, with respect to the contract, are determined normally through the SOW, as well as, the standards and specifications invoked through the SOW.

Therefore, a poorly written SOW, one that is vague, unclear, ambiguous, and not concise, exposes the government and contractor to unplanned and unnecessary risk by making the contract less enforceable, and henceforth, requirements not optimally satisfied. An obvious solution to this problem is to prepare SOWs which effectively convey government requirements. The question then becomes, what skills are necessary to prepare SOWs that are effective and subject to one interpretation.

This paper examines SOW preparation skills based on recent research of over 1,000 Air Force Systems Command program managers and engineers. Drawing on the data from a 65-question survey of this group, the results clearly show that the government is perceived as doing an inadequate job of preparing SOWs in clear, concise, and unambiguous language. The results also show that the government does not adequately prepare government personnel to develop SOWs. Using the results of this research, the SOW preparation process is discussed along with where SOW preparation skills can best be improved. Finally, this paper extends the discussion to a consideration of SOW preparation problems and the development of appropriate skills and competencies to overcome these problems.

INTRODUCTION

Background. Recent initiatives resulting from the 1988 Defense Management Review (DMR) have highlighted the need for better educated Department of Defense (DOD) program managers and acquisition support personnel.[1] The DMR grew out of the findings from the 1986 Packard Commission Report that stressed the need for acquisition reform and more improved educational opportunities for acquisition support. In fact, the Air Force's Acquisition Management Professional Development Program (AMPDP) was a direct outgrowth of the Packard Report. The AMPDP sets stringent requirements for acquisition personnel at three levels, which are indicative of their educational and experience background.[2]

Unfortunately, the courses identified in the AMPDP curriculum fall short of providing adequate education regarding the formulating of program requirements into contractual terms via the SOW. The SOW is important, because, according to the Federal Acquisition Regulation, it is a "comprehensive, performance-oriented work statement that must accurately reflect government requirements."[3] The SOW is a legally binding document that must capture all necessary management functions in support of the government decision process. Recent research, however, indicates widespread confusion, misunderstanding, and misconceptions regarding SOW objectives, guidance documents, and policies. Not surprisingly, this phenomenom is not new. In August of 1980, the Under Secretary of Defense for Research and Engineering tasked an ad hoc group to develop a military standard or handbook to overcome the problems just described. Their charter was to build a standard or handbook to minimize unclear requirements, enhance the quality and inventiveness of proposals, and simplify determining the rights of the contractor and government.[4] The result of this group's efforts was the development of MIL HDBK 245A, Preparation of Statement of Work. The problem with MIL HDBK 245A, now MIL HDBK 245B, is not so much its content, but the fact that it is was a one-time effort to document lessons learned at the time. No follow-on guidance, formalized policy, training, or education was ever initiated. The result has been that government personnel have the choice of following MIL HDBK 245B, thereby creating a plethora of discretionary SOW formats and objectives further clouding the effectivness of the SOW as the primary SPO tasking document. Many times past SOW preparation mistakes are repeated at the taxpayer's expense. The result has also been a lack of SOW preparation education since most AMPDP courses merely reference or reiterate MIL HDBK 245B principles. What is needed is an educational forum where SOW preparation skills can be enhanced, where current SOW writing techniques can be taught, and where lessons learned can be shared to provide the skills in preparing SOWs.

Scope. There are five basic steps in the SOW preparation process that should be considered.[5] The first step is setting government and contractor objectives for the program. Typical issues are potential maintenance concept envisioned, provisioning planning, industrial base planning, and development milestones. This list is not inclusive. The second step is organizing and tailoring SOW formats using MIL STD 881A, Work Breakdown Structure, as guidance. The third step is writing the appropriate SOW tasks, based on MIL HDBK 245B, to match the SOW

structure. The fourth step is negotiating SOW content, which becomes part of the contract, with the contractor(s). Finally, the fifth step is changing SOW requirements, after contract award, as the program matures and changes scope. Although each of these steps is important, the real government "corporate weakness," based on our research, lies in steps two and three. Therefore, in this paper, we have focused our attention to these two steps where education is most needed and can be applied most effectively.

We surveyed 2,264 Air Force Systems Command (AFSC) program managers in 1988-89, in Air Force Specialty Codes 26XX through 28XX, to flesh out what skills were needed, what topics should be included, and what problems were encountered in completing steps two and three of the SOW preparation process. Each respondent received a 65-question survey structured to identify demographic data, to weight their relative SOW experience levels, to explore their primary SOW development techniques, and to categorize common SOW preparation problems and recommended solutions. The range of respondent demographic data covered almost all paygrades, locations with the Air Force, and levels of experience. The average survey respondent was a captain, with a technical background, who worked in or for a System Program Office (SPO). Significant to our survey was the fact that nearly seventy percent of those responding had been responsible for preparing more than three SOWs in their careers. Of the 2,264 surveyed, 1,038 responses were received for a forty-six percent return rate. We consider this phenomenal response to be an indicator of the consensus of concern about SOW development. These 1,038 responses included more than 650 handwritten comments covering the full gamut of concerns on the SOW process.

CURRENT PERCEPTIONS

Problem Identification. The problem with the SOW preparation process is two-fold: a lack of validated curriculum, and, secondly, a lack of effective education in this area. In this segment, we want to provide the results of current research which supports our hypothesis that government personnel need SOW preparation education. In Figure 1, the results clearly show the importance of the SOW to the SPO. Figure 2 also supports the contention that SOW development is one of the most difficult tasks the SPO performs. This development typically encompasses steps two through five in the SOW preparation process. Figure 3 directly supports the belief, held by most program managers, that contractor's will always be able to find loopholes in the SOW. This may be one reason why respondents were not quite as confident, as depicted in Figure 4, that current SOW preparation guidance is as specific and adequate as they think it should be. The primary disadvantage in preparing the SOW is not knowing what needs to be done and what to subsequently task the contractor, see Figure 5. One reason for this weakness, as shown in Figure 6, is a lack of education relatable to the SOW they are preparing. Therefore, most program managers and engineers would like to see better educational opportunities in preparing SOWs as can be seen in Figure 7. One respondent's comment summarized this point most effectively, "Too busy hacking at the leaves to get to the root. Under-manned. Under-educated and just have time to work fires." What has not been fully appreciated is the far-reaching impacts of a poorly prepared SOW. Figure 8 supports the perception by Air Force program management and engineering that we do a

FIGURE 1. THE SOW IS ONE OF THE MOST IMPORTANT DOCUMENTS PREPARED BY THE SPO

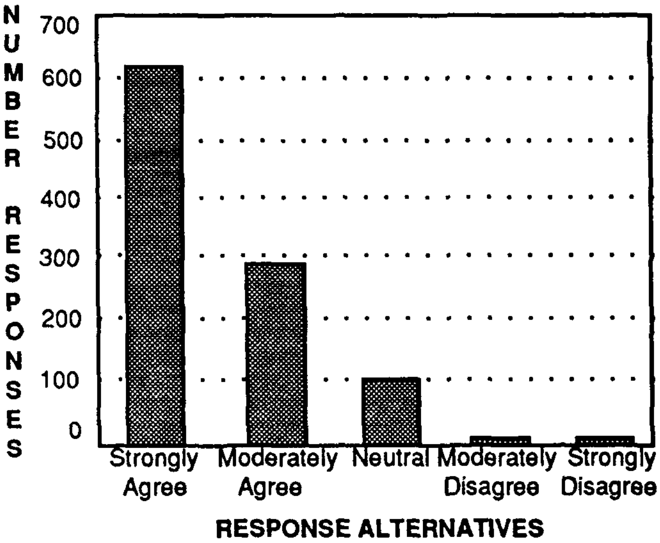


FIGURE 2. SOW DEVELOPMENT IS ONE OF THE MOST DIFFICULT TASKS THE SPO PERFORMS

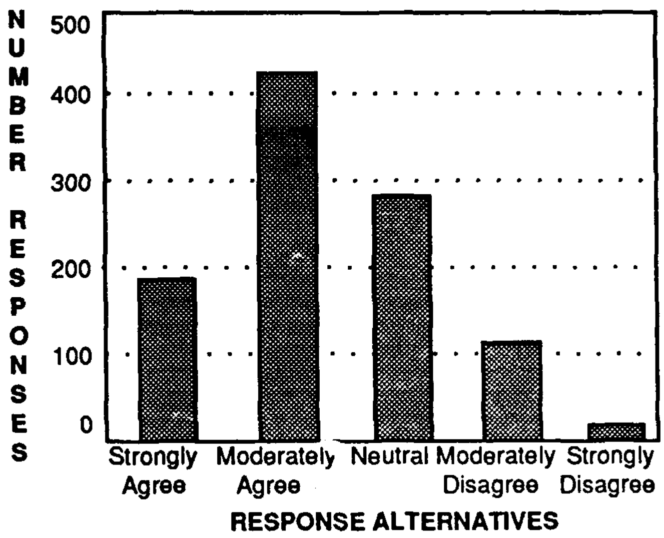


FIGURE 3. CONTRACTORS WILL BE ABLE TO FIND LOOPHOLES IN THE SOW CONTENT

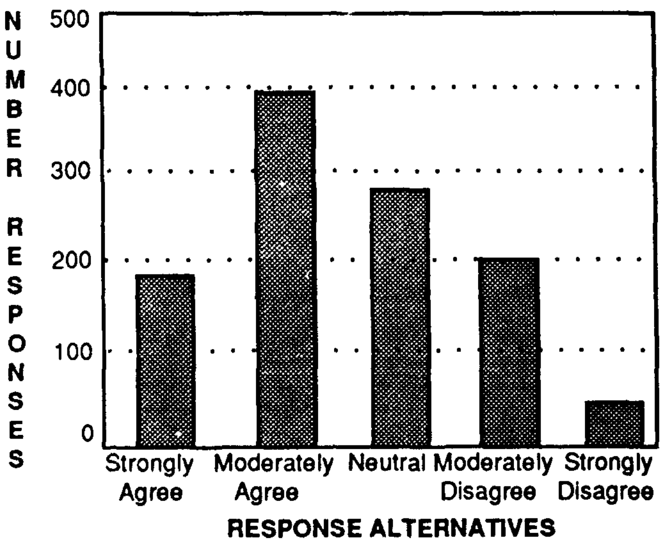


FIGURE 4. THE AIR FORCE HAS SPECIFIC AND ACCURATE SOW DEVELOPMENT GUIDELINES AVAILABLE

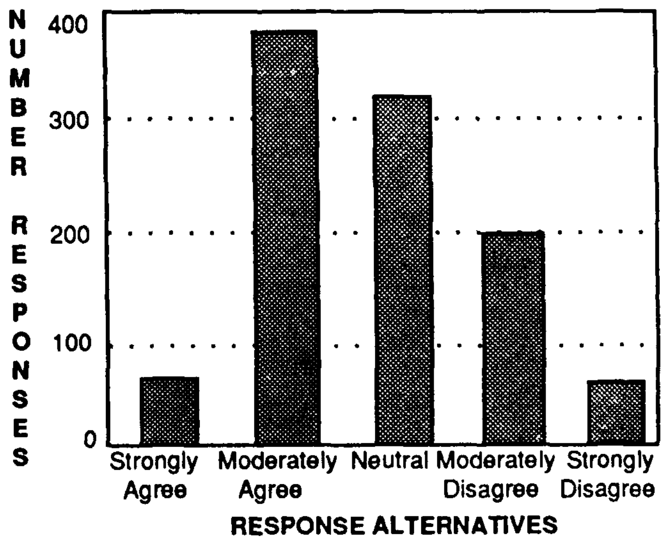


FIGURE 5. THE MAJOR DISADVANTAGE IN DEVELOPING THE SOW IS NOT KNOWING WHAT NEEDS TO BE DONE AND WHAT TO TASK THE CONTRACTOR.

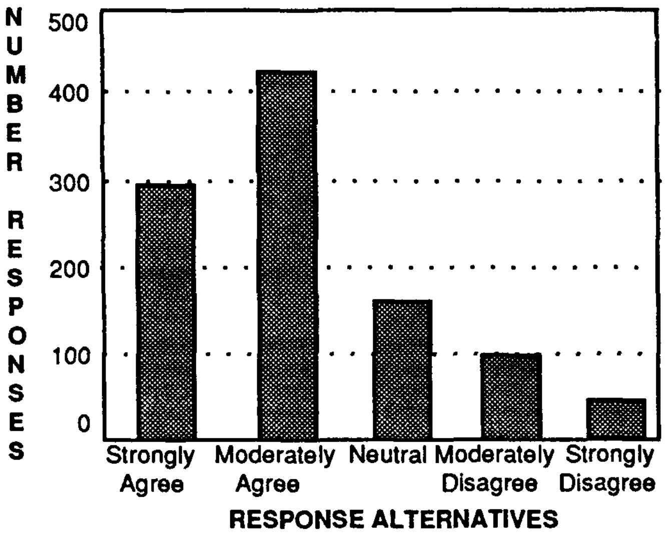


FIGURE 6. MOST GOVERNMENT ACQUISITION MANAGERS HAVE THE NECESSARY EXPERIENCE AND TRAINING TO PREPARE THE SOW.

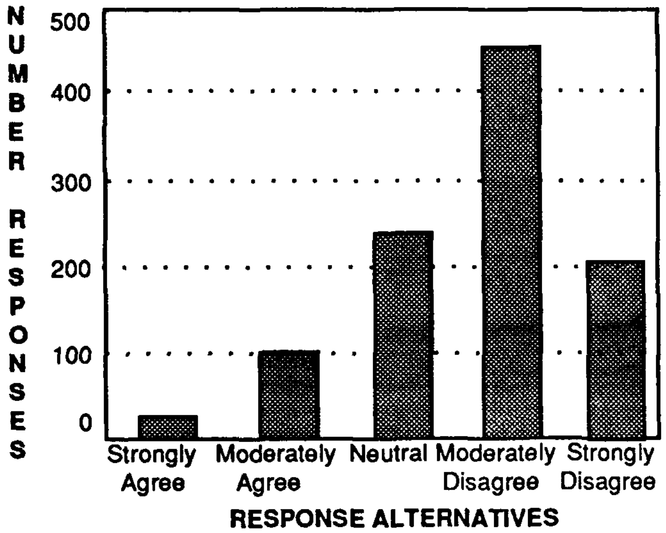


FIGURE 7. I WOULD LIKE TO SEE BETTER TRAINING IN THE AIR FORCE AND BETWEEN SERVICES CONCERNING THE PREPARATION OF SOW'S.

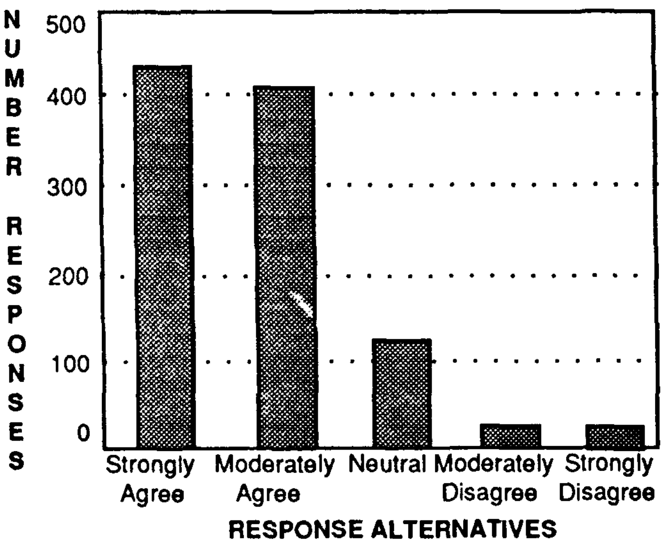
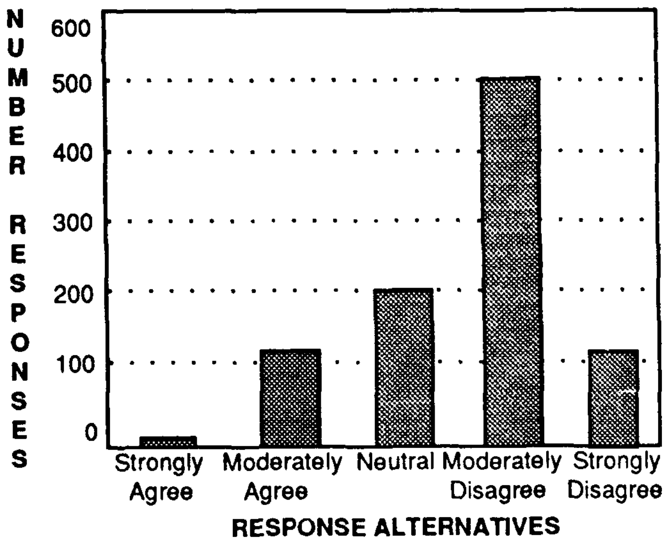


FIGURE 8. SOW'S ARE WRITTEN IN CLEAR, CONCISE AND UNAMBIGUOUS LANGUAGE.



poor job writing SOWs. Since the SOW is the "comprehensive, performance-oriented work statement" in the SPO, according to the FAR, it is used as the baseline for scheduling, risk identification, pricing, and performance measurement. A poorly written SOW builds-in inefficiencies into the program. Getting to well-written SOWs is the point of this paper and our research. Indeed, in many instances, the nurturing of SOW preparation skills is a lost art in many of our most prestigious academic institutions..

Philosophy. Lake[6] has recently stated that the one, key missing ingredient in preparing government program managers and engineers for requirements translation is the lack of a systems engineering perspective. Since the SOW is a comprehensive document, encompassing all tasks the contractor is supposed to do, see Figure 9, one would assume that these tasks are inclusive and integrated by the government before being put on contract. Duplication and misinterpretation should be minimized, while identification of responsibility should maximized. According to Lake, there are three legs to systems engineering: process, product, and people. So often acquisition reformation focuses on the process and the product, but what really needs the fix is the people. In this regard, we agree that the real crux of the "poorly written SOW" perception has to do with the people aspect of the systems engineering philosophy. If we are to make the SOW a comprehensive,performance-oriented document, then people must be educated on how to minimize duplication and misinterpretation and how to maximize responsibility identification. Normally this includes involvement with all acquisition functional areas as depicted in Figure 10. This means that the SOW preparer not only writes the SOW, but many times has to reach consensus with many diverse, and sometimes conflicting requirements. Our purpose, then, is to define what skills are necessary to prepare a comprehensive, performance-oriented SOW realizing there will be conflicting requirements along the way.

Skills Checklist. Our survey asked each respondent to rank order ten areas where SOWs have typically been a problem in the acquisition process. These ten problem areas were developed based on four years of in-class research, at the Air Force Institute of Technology (AFIT), with students enrolled in SYS 200, Acquisition Planning and Analysis.[7] Each survey problem area was identified with either a one, two, three, four, or five indicating the magnitude of the problem. A rating of five was a problem of overwhelming concern; four was a problem of major concern; three was a minor problem; two was not a problem; and, one was not applicable. The ten problem areas they were asked to rank were as follows: grammar and syntax, defining data requirements, development of tasking statements, dealing with time constraints, related program experience, electronic word processing, finding ambiguities and loopholes, group communication skills, interpreting government guidelines, and integrating program requirements. We only considered responses significant where fifty percent of the respondents gave it a four or five ranking. According to our results, the number one problem is the development of tasking statements. The other problem areas were integrating program requirements and defining data requirements. The two areas of least concern were electronic word processing capabilities and grammar and syntax. Using the same ten items just described, the respondents were then asked to rank order these problem areas according to what skills are the most important to the

FIGURE 9. SOW'S SHOULD BE WRITTEN TO INCLUDE EVERY TASK THE CONTRACTOR IS RESPONSIBLE FOR DOING.

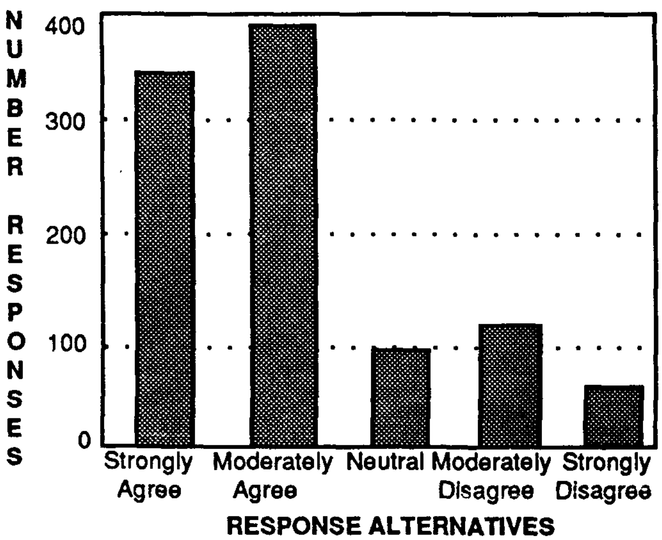
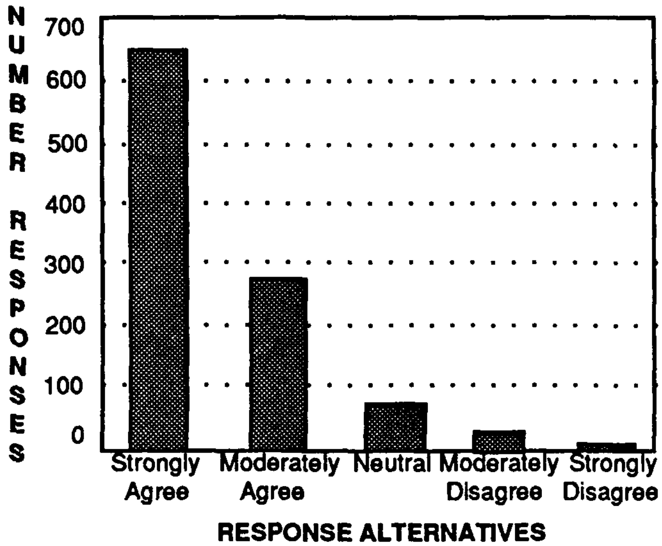


FIGURE 10. A SOW NEEDS TO BE COORDINATED WITH EACH FUNCTIONAL SPECIALTY (LIKE SYSTEM ENGINEERING, CONFIGURATION MANAGEMENT, PROGRAM CONTROL, ETC.) WHEN THE SOW IS BEING DEVELOPED.



least important. For instance, would the ability to integrate program requirements be a more valuable skill to have relative to the ability to define data requirements. Not surprisingly, there was no difference in how the respondents rank ordered with regard to skill preference or problem area. Being able to develop tasking statements was considered the biggest problem area and the most important skill to have, followed by integrating program requirements, and defining data requirements. As one might expect, these are also the primary skills necessary to adequately perform steps two and three of the SOW preparation process.

Skill Expansion. Our research indicates that these skills can and should be further delineated to accurately and adequately prepare government personnel in SOW preparation. Each survey respondent was also asked what competencies they would emphasize if they could design a SOW preparation course. It is our contention that developing tasking statements, integrating program requirements, and defining data requirements are definitely skills to possess, and that these skills can be broken down further into corresponding competencies. Of the 653 handwritten comments, 540 of them, identified defining requirements as the key competency to successful SOW preparation. This includes an understanding of the Work Breakdown Structure, comprehension of user requirements, integration aspects of those requirements, development of the tasking statements to reflect SPO objectives, and how to be flexible in writing style concerning being general versus specific. A thorough knowledge of government regulatory requirements and data issues was also desirable.

The second most highlighted area in our research was team building. Over forty-one percent said that team building could greatly reduce the ambiguity of SOW requirements. Several causes for this are more efficient and effective use of SPO functional managers, contractor personnel,user representatives, and support agencies.

Personal management skills was the third competency highlighted. This area concentrated around familiarity with the technical aspects with the product. A knowledge of past SOW examples was considered valuable, as well as, knowing where to go concerning technical issues. This area differs from team building in the sense that it invokes a person's experience, maturity, and lessons learned on a personal level.

The final area of emphasis was goal setting. Thirty-three percent responded that learning how to set joint and sometimes conflicting objectives, flexibility and adaptability in scheduling, using current guidance and policy, and a sense of humor were absolute essential skills required to prepare a SOW.

CONCLUSION

Recommendation. These competencies are directly applicable to developing tasking statements, integrating program requirements, and defining data requirements. In fact, these skills and competencies are already taught at Defense Systems Management College, AFIT, and other prestigious academic institutions. Unfortunately, there is no guarantee that an individual can make the rounds and attend every course they need, provided they know it exists. Nor are there any courses that teach these specific skills and competencies in the context of preparing SOWs. We have already seen where preparing the SOW is one of the most difficult tasks to perform in the SPO. It is our contention that a

curriculum be developed to include the skills and competencies outlined in this paper. We also propose that a team of SOW experts systematically inject current lessons learned into the curriculum to reflect changes in the law and current business practices. It is this nurturing of SOW preparation skills that will lead to better contracts and, ultimately, better products and services.

Summary. The SOW is the nucleus of our acquisition process, but, unfortunately, it is also the genesis of program problems in many cases. The SOW survey results just described make it clear that the problems associated with SOW development are multifaceted and equally frustrating to managers and functional experts at all levels. More than sixty-one percent of the program managers responses think we, the government, do a lousy job of preparing SOWs in clear, concise, and unambiguous language. We firmly believe that more direct emphasis needs to be placed on an educational program for SOW development, emphasizing the preparation skills and competencies identified in our research.

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PROPOSAL ANALYSES BY FAST ACTION NEGOTIATION GROUP (FANG) TEAMS

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ABSTRACT

This paper highlights team-building and how FANG Teams accomplish four tasks: 1) **recognize** opportunities for expedited analyses (workarounds) that simultaneously negotiate multiple change proposals; 2) **plan** team assignments and build agendas that harness technical fact-findings into proposal baselines; 3) **execute**, translate price fact-findings into quality contracts and; 4) **motivate** individual team member performance to overcome challenges by sharing strategies and rewarding professionalism. Benefits gained from using the above tasks during July 1989 through January 1990 include the following: enhanced reliability of proposal management information; eliminated wasteful duplications of negotiations; accelerated awards of contract modifications; and reduced acquisition costs. Groupings of negotiations for nine modifications having a cumulative bid value of $47 million led to cost efficiencies wherein nine change proposals were awarded in the time normally needed to complete one award. Consolidations of equipment purchases into economic order quantities avoided over $7 million of nonrecurring costs. Beginning in February 1990, all of ASD/YW began to institutionalize portions of the FANG tasks and, as a result, has acheived unsurpassed quality.

INTRODUCTION

Let's understand how accumulations of technology insertion requirements, weapon system changes and real-world acquisition milestones necessitate rapid responses and real-time creations of FANG Teams. Real-world pilot training requirements in support of operational weapon systems such as the multi-configured F-16 create program conditions. Program conditions drive acquisitions and deliveries of F-16 Weapon System Trainers at the same time that the manufacturer of the F-16 delivers equivalent configurations of F-16 aircraft. Such training system requirements are widely known as concurrency goals and program changes. Concurrency goals generate contractor changes to existing contracts and in turn lead senior decision makers to commit resources toward challenging delivery schedules. In order to achieve challenging acquisition delivery schedules, FANG Teams are created to workaround and overcome accumulated delays in negotiating change orders and an increasing volume of change proposals.

Understand that FANG Teams are created to rapidly produce bilateral contracts (supplemental agreements). Supplemental agreements supersede unilateral change orders not mutually agreed upon by the government and the contractor. Methods used to obtain rapid mutual agreements for five change orders and four change proposals are shared in this paper. Mutual agreements established contractual coverage for four different integration modifications, five new technical efforts, revised statements of work, updated specifications, added contract data requirements, new delivery schedules, and other terms and conditions. The variety of mutual agreements required a FANG Team consisting of a variety of professional specialists supporting government program offices/contractor offices. Individual FANG Team members are specialists selected from the following offices: Program Management, Contracting, Engineering, Logistics, Funds Management, Manufacturing, Data Management, Test, Configuration, Pricing, and Auditing.

Tasks #1 thru #4 that follow describe experience-proven samples of questions asked by FANG Teams. Candid answers to FANG Team questions are needed to enforce proposal preparation discipline and technical evaluation quality standards. Discipline and candid answers help achieve fair and reasonable mutual agreements. For future training purposes, FANG tasks summarize proposal estimating standards, sample technical evaluations, and referenced ASD/YW Operating Instructions.

TASK #1.

Recognize contractor opportunities to: reduce non value-added costs, reduce administrative delays, reduce defective pricing, accelerate corporate captures of revenues, retain more company profit, enhance stockholder benefits, increase external customer (goverrnment) benefits, increase internal corporate satisfaction, increase mutual trust between government and contractor acquisition teams, and establish a framework for further total quality management process improvements.

Program Indicators

Early identification and definitiion of technology requirements can lead to cost efficiencies early in proposal preparation. For the first time, challenging program delivery schedules and cost efficiencies prompted ASD/YW to establish two teams (FANG #1 and FANG #2) during July and October 1989. The FANG teams ranked 9 of the 12 highest priority change proposals and grouped overage proposals in accordance with related avionics equipment and requirements termed block modifications of the F-16 Weapon System Trainer. The four top priority- and oldest-change proposals were settled by FANG Team #1 during July 1989. However, nonavailability of FANG Team #2 members and incomplete proposal status delayed settlements on five change proposals

until October 1989. Photos of integrated training equipment acquired through FANG teamwork are shown on the last page of this paper.

Limited visibility into proposal content and program milestone status prompted parallel decision-making by negotiation team chiefs to recognize challenges, plan agendas, execute plans, and motivate professional performance. In order to realistically plan milestone completion dates and update program status, program managers systematically asked assigned estimators to group technical similarities and monitor statements of work/specifications provided by engineers and others.

Trend Analysis

Contractors and government teams use Acquisition Management Information System Reports and Program Planning Reports to do trend analyses. Such trend analyses usually need more credible rationale for estimating milestone completion status. Updating of status and milestone completions continues to be challenging for program managers because acquisition planning reports rarely are developed and derived from proposal credibility or contractor rationale regarding engineering or acquisition support estimates. Also government technical evaluations of such estimates usually take weeks of preparation. Checks and balances regarding quality of proposal preparation and government technical evaluations are needed to establish credible planning status. An acquisition problem solving method used to establish reliable milestone status and expedite initial proposal analyses has been defined as a workaround. Several expedited proposal analyses are called workarounds. Workarounds. Real-world commitments to customers necessitate real-time management visibility in order to research technical disputes. A successful method has been delegation of authority from senior management to single focal points and then holding each focal point (negotiation team chief) personally accountable for assuring appropriate workarounds are done prior to pre-negotiation briefings and negotiation clearances. In order to obtain cost efficiencies early in proposal processing and maintain disciplined accountability, senior decision makers should assure as a minimum that, each negotiation team chief:

- Understands technical summaries of the subject proposal.
- Assesses the necessity of proposal efforts.
- Identifies any duplication in proposal efforts.
- Adjusts any omissions or failures to propose necessary efforts.
- Verifies appropriateness of estimating techniques, complexity factors, and cost estimating relationships supporting the proposal.
- Quantifies schedule and workload that affect historical cost bases used to project proposal costs.
- Compares availabilities of bid resources with competing bids anticipated as being done during the same time period.
- Provides traceable rationale to support a proper mix and sequencing of skills needed in specific labor categories.
- Estimates realism and reasonableness of direct labor hours.
- Audits the need by type or quality of material.
- Prices reasonableness of subcontractor proposed material efforts.
- Validates the need for purchasing subcontractor equipment.
- Checks for available government furnished equipment/property.
- Justifies contractor trips to bid locations.

TASK #2.

Plan, build agenda commitments and use technical interchange meetings to harness written and verbal communications during technical fact-findings. Technical fact-findings focus traceable statements of work into agreed-upon technical baselines. Specific efficiencies of TASK #2 depend, to a large extent, on disciplined team member understanding and accepting accountability for specific responsibilities and information. Each member is trained that timely, accurate data inputs are expected. Such expectations are achieved by accomplishing the following eight steps to plan implementation of FANG Tasks.

- Define what needs to be done.
- Select who is to do what.
- Identify when tasks are to be done.
- Document why tasks are necessary.
- Set up a tracking system to monitor implementation.
- Develop procedures and standards as needed.
- Use periodic audits to measure progress of planned actions.
- Communicate a clear, concise plan needed to obtain technical baselines.

Technical Baselines

Technical baselines are agreements that define equipment configurations and technical requirements. Baselines are derived from contractor estimates and government evaluations. Any technical estimates and government evaluations relying on judgement should be summarized at cumulative price levels. Proposal task descriptions should explain details of work to be performed. Rationale needs to accurately reflect recommendations in developing the estimate. Manhours and durations of tasks should match associated task descriptions. Prior experiences of estimators on other programs should be used to develop estimates and such programs should be cited by name. Negotiation team chiefs should assure availability of estimators for audits and technical fact-findings by maintaining lists of estimators using judgement within estimates.

Technical Fact-findings

Technical fact-findings need to explain underlying reasons for any differences between contractor estimates and government technical evaluations prior to starting negotiations. Government technical evaluations are time intensive and can delay negotiations. In order to avoid delayed technical fact-findings due to in-scope and out-of-scope disagreements, simulator configuration rationale should be very well documented in the Design Criteria List (DCL) and frozen. Experience has proven that the DCL frequently is

an under-used, configuration/contractual control document regarding in-scope and out-of-scope efforts. However, engineering requirements in the DCL should be clearly defined during technical fact- findings in order to avoid delayed contract awards. Thus the DCL and associated freeze agreements should be clearly explained in the SOW. Contents of DCL should include technical orders, memos, teleconferences, flight manuals, drawings, photographs, and so on. Current, complete airframe data packages need to be obtained from the Airframe Contractor. Agreed-upon freeze rationale for proposals should be documented in Data Item Description DI-H-3276 (Criteria List-Simulator Design) by preparers of the estimates. Systematic and standardized evaluations should be based upon thorough technical fact findings that define what the subject DCL encompasses. Adverse effects of less-than-comprehensive estimator rationales and technical evaluations are price negotiations wherein government program managers and government engineers try to redefine acquisition requirements and obtain contractor concurrences.

TASK #3.

Execute, implement the plan to translate price fact-finding commitments into quality contractual vehicles that enhance likelihood of fair and reasonable price settlements. Teams need to be given samples and trained to document price estimates and cost rationales by answering key questions:

- Does the proposal meet Corporate estimating and cost accounting standards?
- What will be acquired, modified (hardware, software)?
- What are the experience bases for estimating the contract schedule?
- What are the customer's needs in terms of capability enhancements, fixing capability shortfalls, and schedule requirements?
- What are the dates of requested status milestones in terms of changes and revisions to the proposal?
- What are the key issues in terms of fund type (3600, R&D; 3010, Production; 3400, O M&S), and fiscal year funds availability?
- What are the configuration baselines shown in the most current proposal?
- What cause any differences in bid costs versus evaluated costs?
- Where are prime contractor rationales of subcontractor quotes and inter-company work order bids?
- Are there differences between final technical proposal and government evaluations of specifications and approved configuration control board directives?

Price Fact-findings and Negotiations

At least four work days prior to face-to-face fact-findings each negotiation team chief agrees in writing to support specific agenda meetings. Team chiefs match availability of resources (who/where/when/how many/how long) to communicate disciplined, systematic rationales of each functional team member position. Contractor and government inputs are provided by specialists from Program Management, Configuration Management, Data Management, Engineering, Manufacturing, Auditing, Pricing, and others. Written positions regarding concurrent simulator development efforts and aircraft production efforts provide analytic approaches to decide which proposal efforts are in-scope and out-of-scope of the contract. Expedited price agreements (handshakes) depend, to a large extent, upon reproducibility of pricing documents. Contractors are required by the Truth in Negotiations Act (Public Law 87-653) to provide government negotiation teams with current cost and pricing data that clearly, completely, and accurately discloses costs before the handshake date.

Challenges during price fact-findings largely developed from proposal credibility or contractor rationale regarding engineering or acquisition support estimates. Also, government technical evaluation of such estimates usually take weeks of preparation. Checks and balances regarding quality of proposal preparation and government technical evaluations are needed to establish credible planning status. Largely, challenges during price fact–findings focus on the comunication challenges that follow.

Communication Challenges

By definition, any condition or team member's performance that adversely affects timely accomplishment of assigned tasks generates a communication challenge. Each agenda item can become a communication challenge unless team chiefs closely and continually monitor evolving proposal updates and clarifications.

Proposal Updates

Teams can improve cost proposal updates and revised technical proposals by using compatible software and architect free hardware. Use of compatible software disks facilitate changes to spreadsheet- and word processing- diskettes instead of mailing bulky document packages. Contractor teams need to update proposals and technical rationales in a timely fashion. Updated rationale should be clearly cross-referenced and accurate. Teams should use single corporate points of contact to verify subcontractor information.

Draft Contracts

Team negotiators can expedite contract awards by writing sample, advance contract terms and conditions drafted prior to handshakes on price settlements. Draft terms and conditions avoid arbitrary schedules from driving vague, bottom-line price settlements that generate avoidable delays in writing terms and conditions. Such avoidable delays arise because rather than merely processing contract files there are disproportionate amounts of administrative clarifications needed to resolve vague terms and conditions.

Audit Reports

Auditors provide useful information but delayed receipts of audit reports arise from teams being unable to readily determine which DCAA office has yet to receive relevant and complete cost data for assigned audits. Teams need to make frequent use of Liaison Auditors located at Wright– Patterson AFB. Professional DCAA liaison auditors have helped resolve adverse opinions regarding acquisitions. Liaison Auditors provide an administrative vehicle, a proven but under-used mechanism, that can expedite quality reports.

Proposal Clarifications

Incomplete contractor clarifications of DCAA positions on proposals sent to geographically separated DCAA activities can delay resolutions of incomplete audit positions. Delays occur because chain of custody/accountability limit quality control to and from Administrative Contracting Officers and price analyists from subcontractors and geographically separated company/divisions. Quality control of negotiations regarding DCAA questioned costs and unsupported costs should address specific facts as well as interpretations of cost estimating deficiency positions and Cost Accounting standards. Contractors should promptly send backup cost and pricing data relevant to the subject proposals to auditors and contracting officers. Teams need to resolve DCAA questions about periods of performance and labor rate recommendations. Negotiation clarifications should cross-reference final proposal of record efforts with original proposals and DCAA Audit (SF 1411) Parameters.

TASK #4.

Motivate team members to overcome people challengesand program challenges by rewarding professional performance; sharing operating instructions; and documenting results for Joint Industry and Government Conferences such as this conference.

People Challenges

Regarding personal team member needs for recognition, team chiefs can maximize benefits of front end planning by sharing experiences and understanding each team member's self-expectations and then seeking to help each person improve self-expectations. Improved self-expectations surface when professional performance is rewarded. Professional performance is evident when individuals complete assigned tasks as promised. Rewards can be non-monetary or monetary. As effective rewards or motivators for performance, non-monetary recognition or respectful appreciations can be valued as much as monetary incentives. Further, inexperienced team members need on-the-job-training how to minimize communication challenges and program challenges. In addition, people challenges can be overcome by each negotiation team chief who:

- Cares, understands about people needs and limitations.
- Keeps promises.
- Forgives people mistakes.
- Advocates rather than blames.
- Speaks in a non-threatening, nondefensive way to challenges.
- Seeks responsibility and accountablility.
- Makes decisions based on accurate, current facts.
- Initiates imaginative solutions that fit specific facts.
- Follows through on solutions.
- Uses experiences, knowledge, and humor to avoid angry conflicts.
- Executes plans that are flexible and responsive to changing facts.
- Rewards performance, documents help given, and shares credit.

Program Challenges

Prior to establishing ASD/YW Operating Instruction (OI) 70-4 and revising ASD/YW OIs 800-26; 70-1; 70-3 in 1989 three program challenges had hindered ASD/YW managers and CAE Link FANG managers from establishing FANG Teams to consolidate and restructure change proposals. First, there was little if any, end-of-tour overlapping for arriving/departing short notice transfers of experienced military- and civilian- managers. Experienced managers need to train inexperienced replacements and monitor frequent disposals of technical evaluation files. Incomplete proposal histories and inexperienced negotiation teams tended to perpetuate decision making by less-informed, under-supervised team members having little, if any, knowledge of detailed FANG Tasks. Second, workload priorities caused more experienced program managers to primarily plan Source Selection acquisitions rather than seeking suggestions how to verify and estimate acquisitionplanning suspenses (milestone dates) of change proposals. Third, undisciplined compliance with Contract Provisions and Federal Acquisition Regulation Requirements adversely affected quality of change proposals and thereby delayed fact-findings and negotiations.

SUMMARY OF RESULTS

Here are the facts and figures regarding FANG Team Results from consolidating and restructuring nine (9) change proposals from July 1989 through January 1990. The two FANG teams awarded nine supplemental agreements (5 change order definitizations and 4 change proposal definitizations) in an average of 221 days. By contrast, a six-month Headquarters Air Force Systems Command study of undefinitized contractual actions reported that the command-wide average for definitizing supplemental agreements (over $500,000) was 264 days from July 1989 thru January 1990. By comparison, ASD wide, the standarrd is 329 days and the standard pursuant to Federal Acquisition Regulations is 180 days. Statistically the 5 FANG definitizations of change orders took respectively 529-, 371, 176, 132, and 92- days (an average of 260 days to award). By contrast, the other 4 FANG definitzations of change proposals took respectively 240-, 160-, 150-, and 141-days (an average of 172 days to award). The FANG Team #1 avoided $4 million in nonrecurring acquisition costs. The FANG Team #2 avoided over $3 million in nonrecurring acquisition costs. Beginning in February 1990 the entire System Progam Office institutionalized portions of FANG tasks. By July 1990, total ASD/YW undefinitized contractual ctions had been reduced from 18 to zero. Finally, the ASD/YW definitization average decreased from 234 days to 158 days.

CONCLUSIONS

There are essential opportunities for improvement. The facts and figures indicate that more widespread use of FANG Teams could avoid significant nonrecurring costs and expedite supplemental agreement awards. Combining negotiations for related change proposals reduces duplication of negotiation efforts by systematically negotiating several changes once rather than conducting several subsequent individual negotiations.

Successful results of FANG Teams accumulate from recognizing opportunities; disciplined planning; executing plans; and motivating professional performance.

Proposal analyses are journeys, not destinations, that should help rather than hinder contract awards. Motivated, trained people identify, verify, quantify, and combine requirements. People expedite mutual agreements by providing verifiable audit trails of contract memorandums.

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ABOUT THE AUTHOR

Bill Callaway has 17 years of acquisition experience in auditing, pricing, and negotiating contracts for the USAF and Defense Logistics Agency. Bill earned an ASD Procurement Contracting Officer (PCO) Warrant on 22 July 1988 from the ASD/PK Board for Contracting Officers. Bill received Certificates in Contract Management, Cost-Price Analysis, and Estimating. Bill holds three degrees: M.S. in Systems Management from the University of Southern California and B.S./A.B. in Business Administration/Arts & Sciences from West Virginia University.

REFERENCES

The 12 references listed below represent the guidelines most frequently used by the subject FANG Teams. Although more supplemental regulations and policies may be needed to tailor specific purchases with different military services, knowledge and proper application of referenced guidelines coupled with common sense judgements should enable trained people experienced in seizing opportunities to overcome challenges previously mentioned in this paper.

- Federal Acquisition Regulation (FAR) Subchapter C, Subpart 15.8, Contracting by Negotiations, 1 April 1986
- DOD FAR Supplement, Part 217, Special Contracting Methods. 1988 Edition
- MIL-STD-1521-b (USAF), Technical Reviews and Audits for Systems, Equipments, and Computer Software, 4 Jun 85.
- MIL-STD-480-a, Configuration Control-engineering Changes, Deviations and Waivers, 29 Dec 78.
- MIL-STD-483, Configuration Management Practices for Systems, Equipment, Munitions, and Computer Programs, 4 Jun 85.
- DODI 5000.50, Defense Acquisition Executive Summary, 23 Mar 89.
- ASD/YW OI 800-24, Engineering Change Management, 6 Nov 86.
- ASD/YW OI 800-26, Program Director's Assessment Report Procedures and Guidelines, 8 Nov 89.
- ASD/YW OI 800-27, Engineering Data Acquisition, 30 Jun 87.
- ASD/YW OI 70-1, Management of Not-To-Exceed (NTE)/Not Less Than (NLT) Priced Contracts, Order, and Modifications to Contracts, 15 Aug 89.
- ASD/YW OI 70-3, Contract Change Proposal Management, 15 Aug 89.
- ASD/YW OI 70-4, Request for Technical Evaluation of Proposals, 29 Sep 89.

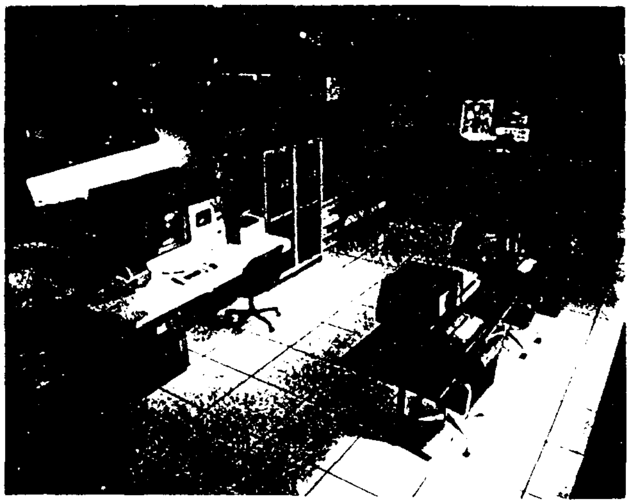

Figure 1: F-16 WST Complex, Luke AFB, Arizona. Shows entire complex with LANTIRN (Low Altitude Navigation and Targeting Infra Red for Night) Simulator.

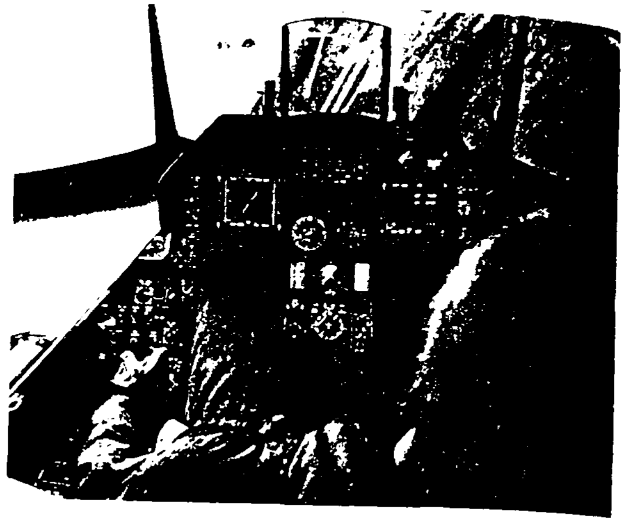

Figure 2: F-16 WST Complex, Luke AFB, Arizona. Shows in cockpit view of Limited Field-of-View Visual Display

Figure 3: F-16 WST Complex, Luke AFB, Arizona. Shows Instructor/Operator station.

Figure 4: F-16 WST Complex, Luke AFB, Arizona. Shows Improved Electronic Warfare Training Device (IEWTD) and Improved Digital Radar Land Mass (IDRLMS) control consoles.

CHANGES IN PROCUREMENT INTEGRITY AND POST-EMPLOYMENT RULES

Major Andrew D. Fallon, U.S.A.F

ABSTRACT

Government employees, especially those in procurement related fields, need to be constantly aware of the wide range of statutory and regulatory ethical standards of conduct limitations. Such ethical standards place limits on the actions of government employees which many other Americans do not face. Government employees are prohibited from accepting certain gifts and from revealing information. They have limitations on what employment they may accept after leaving government service, and they even have limitations on when and with whom they may discuss future employment possibilities.

The purpose of this paper is to point out the changes which have been enacted in procurement integrity and ethical standard of conduct rules during the last year, especially those changes in the restrictions on post-government employment of former government officers and employees. After a brief background look at the major post-government employment restrictions, the changes to the Procurement Integrity provisions (41 U.S.C. section 423) will be examined. Next, the criminal post-employment rules found in Title 18 United States Code (18 U.S.C.), which were modified by the Ethics Reform Act of 1989, will be reviewed. Finally, a look at the changes proposed by the latest Bush Administration proposal will be provided in order to help government employees determine where ethical standards and post-government employment restrictions may be going in the near future.

Background

Ethical standards of conduct and procurement integrity rules have seen many changes and legislative initiatives in the last few years. Several of the changes which most directly effect post-government employment restrictions of former government officers and employees were suspended for a one year period, from December 1, 1989 to November 30, 1990. In November 1990, that suspension of the post- employment restrictions was extended for an additional six months.[1] The three main laws suspended were:

a. the Procurement Integrity provisions (Section 27) of the Office of Federal Procurement Policy Act (41 U.S.C. 423);

b. Section 2397a and 2397b of Title 10, United States Code (10 U.S.C. 2397a and 2397b); and

c. 18 U.S.C 281.

The Procurement Integrity provisions limit the post-government employment of government employees who have been "procurement officials." These provisions are discussed in greater detail below.

10 U.S.C 2397a requires government employees in the grade of

GS-11 or O-4, or higher, to report all contacts concerning future employment with a defense contractor if they are performing "procurement functions" on that defense contractor's contract. 10 U.S.C. 2397b prohibits certain former government employees from accepting any compensation from large DoD contractors for two years after they leave the government if they performed certain procurement duties during the last two years of their government service. If the former government employee was a GS-13 or O-4 or above, the prohibition would apply if they spent a majority of their working days performing procurement functions at a plant or site owned or operated by the contractor. It would also apply if they spent a majority of their working days performing procurement functions on a major defense system involving that contractor. If the former government employee was an O-7 or Senior Executive Service (SES) or above, the prohibition would apply if, during their last two years of government service, the individual served as a primary negotiator for the government concerning a contract or claim of the private contractor worth $10,000,000 or more.

18 U.S.C. 281, the third of the suspended restrictions, prohibits retired military officers from selling anything to the military department from which they retired for a period of two years after retirement. It also prohibits, for two years after retirement, military officers from assisting in the prosecution of a claim against the United States involving the department from which they retired, or concerning matters they were connected with while on active duty.

A law similar to 18 U.S.C. 281 (37 U.S.C. 801) which provides for the forfeiture of retired pay of a retired regular military officer if he or she sells supplies or war materials to the DoD within three years of retirement, was not suspended and is still in effect.

The purpose of the suspension period was to enable Congress to examine the various procurement integrity and post-government employment restriction laws and determine their compatibility with the newly enacted, government-wide Ethics Reform Act of 1989.

Despite the suspension of effect of these ethics laws, there have been statutory amendments and other changes to the procurement integrity standards.[2] The Ethics Reform Act, which became effective on January 1, 1991, also made major changes to the criminal conflict of interest laws contained in Title 18, United States Code, directly effecting the ethical requirements and post-government employment restrictions of former government employees. In addition, the Bush Administration has proposed and Congress is considering a proposal which would provide major changes to the procurement integrity and ethical standards of conduct laws.

Procurement Integrity

The Procurement Integrity laws, which were first enacted as a part of the Office Of Federal Procurement Policy Act in 1988, were designed to provide broad restrictions on the relation-

ships between government contractors and the government employees they worked with. The restrictions were very specific with regard to releasing confidential procurement information and the employment by private contractors of former government employees who had performed work for the government on a contract involving that private contractor.

The Procurement Integrity rules caused a lot of confusion and concern for both contractors and government employees. In fact, there was so much confusion concerning the rules that, although they were originally scheduled to become effective in May 1989, Congress delayed their effective date until July 16, 1989,[3] in order to give all parties involved more time to become familiar with the new requirements. Even when the Procurement Integrity provisions did become effective in July 1989, complaints about them continued. Congress, in enacting a new law, The Ethics Reform Act of 1989, decided to suspend the effectiveness of the Procurement Integrity provisions for a period of one year from December 1, 1989 to November 30, 1990.[4] At about the same time, Congress passed another new law which provided changes to the Procurement Integrity provisions.[5] Since the basic provisions of the Procurement Integrity law were suspended, the changes provided by the new law were suspended as well. Consequently, they had no real effect on government employees or private contractors until December 1, 1990. To complicate matters even further, in November 1990, Congress decided to continue the suspension of effect of the post-government employment restrictions of the Procurement Integrity laws for an additional six months,[6] which means that many of the ethics restrictions concerning post-government employment of former government officers and employees will not be effective until May 31, 1991.

Various other provisions of the Procurement Integrity laws, such as the certification requirements and the prohibitions on releasing proprietary or source selection information, did become effective law as of December 1, 1990. If suspension of the post-employment portion of the Procurement Integrity law ends as scheduled, the changes made while the Procurement Integrity law was suspended, will finally become effective.

One of the changes included in the new law, which did become effective December 1, 1990, was to define exactly which government employees were to be considered "procurement officials." Such a definition is important since the prohibitions and restrictions included in the Procurement Integrity law generally apply only to government employees who are "procurement officials" not to all government employees.

The definition provided by the statute includes any civilian or military officials or employees of the government who had participated "personally and substantially" in any of the following activities on a specific procurement:

a. the drafting, review or approval of a specification developed for the procurement;

b. the preparation or issuance of the solicitation;

c. the selection of sources, or the evaluation of bids or proposals for the procurement;

d. the conduct of negotiations in the procurement; or,

e. the review or approval of the award, modification or extension of a contract.[7]

The definition of "procurement official" in the new law provides no significant change to the Procurement Integrity rules since it is the same as the definition which was provided in the Federal Acquisition Regulation (FAR) when the Procurement Integrity rules were first made effective in July, 1989. This change in the law should not, therefore, cause any real change in the ethical requirements for government employees since they were already required to follow the standards set forth in the FAR.

The first major change to the Procurement Integrity rules contained in the revised law provides government procurement officials the opportunity to recuse themselves. That is, they may voluntarily remove themselves from taking any action in their official capacity regarding certain government procurements. The Procurement Integrity laws originally prohibited any government "procurement official" (as defined above) from soliciting, accepting, or even engaging in any discussion about future employment or business opportunities with a private contractor who is competing for a contract with which that government official is involved. The law also prohibits such a procurement official, even after they have left government service, from working for a private contractor on the performance of the awarded contract, or as a negotiator for the contractor concerning award, modification or extension of such a contract, for two years after the government employee ceased working on that contract for the government.

Under the new law, a procurement official who recuses him or herself from further official actions with regard to a certain procurement, may avoid the prohibitions against seeking or accepting future employment with private contractors who are competing for the award of that contract. Contractors are also allowed to make offers of employment to procurement officials if the procurement official has properly been recused from the procurement in question.

To be properly recused, the procurement official must submit, in writing, a request to disqualify themself from conducting any procurement related activity concerning the contractor or contractors with which they are seeking or considering employment. He or she then submits the recusal request to the Head of the Procuring Activity, who must approve it in writing. The Head of the Procuring Activity may reject the recusal request if they determine the procurement official is too important to be removed from the procurement, or for a variety of other reasons. A recusal may not be granted if the procurement official has participated personally and

substantially in the evaluation of bids or proposals, the selection of sources, or the conduct of negotiations in connection with the solicitation. In addition, a request for recusal may not be granted for a procurement official who participated personally and substantially in the negotiation or evaluation of a contract extension or modification, or even a decision not to modify or extend a contract.[8]

A second change contained in the new statute clarified the status of subcontractors with regard to the prohibitions against "competing contractors." "Competing contractor" is another term defined in the Procurement Integrity law and it means any entity which is currently competing for, is likely to compete for, or will be the recipient of a contract or subcontract concerning a government procurement.[9] All "competing contractors" are prohibited from making offers of future employment or engaging in discussions about future employment with procurement officials, offering anything of value to procurement officials, or obtaining any proprietary or source selection information from agency employees. These prohibitions parallel the prohibitions on procurement officials discussed above.

In the original statute, these prohibitions were applicable to prime contractors and subcontractors at any level in a government procurement. The revision to the procurement integrity laws now places a limit on which contractors are subject to these limitations. Only prime contractors, first and second tier subcontractors who's contracts are for more than $100,000, and those subcontractors who "significantly assisted" the prime contractor in the negotiation of the prime contract or were selected, recommended or approved for award of the subcontract by the procurement official involved are subject to the statute's prohibitions.[10] So, under the latest revision, not all subcontractors are included in the law's prohibitions.

A third change, which has relatively limited applicability, authorizes the President to grant waivers to certain civilian government employees of the two year post-employment restrictions. Such waivers are limited to no more than 25 persons and may only be granted for employment at a Government--owned, contractor operated facility if the President determines the individual's services are critically need for the benefit of the Government.[11]

Ethics Reform Act

In late November 1989, Congress also passed The Ethics Reform Act of 1989, which extensively modified the criminal post-government employment laws concerning government employees. These laws are found in Title 18, United States Code section 207 (18 U.S.C. 207.) These post-government employment restrictions are broader than the post-employment restrictions contained in the Procurement Integrity law since they restrict post-government activities of all executive branch employees, not just those who meet the definition of "procurement officials." Congress made the new changes effective

beginning January 1, 1991.

The criminal post-employment restrictions contained in Title 18 U.S.C. do not specifically restrict employment of former government employees with private contractors, rather they prohibit certain activities of former government employees. The restricted activities typically include: " knowingly mak-[ing], with intent to influence, any communication to or appearance before any officer or employee of any department, agency, court or court-martial of the United States..."[12] The restriction against making "any communication" with "an intent to influence" is very broad and intended to be so. It was designed to prohibit any post-government employment activities of a former government employee if they include any direct dealing or communication with the U.S. Government.

The prohibition against making any communication to an officer or employee of the United States with an intent to influence them would seem to prohibit many employment activities with private contractors. Even though 18 U.S.C. 207 would not prohibit the employment of a former government officer or employee with a private contractor, that former government employee would be prohibited from negotiating with the government, asserting claims, selling products or services, or even making presentations or serving as a liaison or representative of the contractor, if any contact (whether orally, in writing, or through electronic transmission) were made with any government official with an intent to influence. Behind the scenes activities, that is where the former government employee only assists or advises others who do the direct dealing with the government, are not prohibited by this law.[13]

The method by which such a broad restriction is made tolerable, and former government employees can qualify for some types of post-government employment with defense industries, is that the restrictions are made applicable only to "particular matters" on which the employee "participated personally and substantially" or "-particular matters" which were under the "official responsibility" of the former government employee. That is, the broad restriction of no contact with any intent to influence is limited only to particular matters in which the employee participated personally and substantially for the government, or which were under the employee's official responsibility.[14]

The term "particular matter" is defined in the law as including "any investigation, application, request for ruling or determination, rulemaking, contract, controversy, claim, charge, accusation, arrest, or other judicial or other proceeding."[15] Since a contract is specifically listed in the statute, a contract is always considered a "particular matter." A former government employee who had either participated "personally and substantially" on a contract for the government, or had had a contract under their "official responsibility" would be subject to the restrictions of 18 U.S.C. 207.

The next key question then be-

comes: what is personal and substantial participation? The statute defines participation as any "action taken by an officer or employee through decision, approval, disapproval, recommendation, the rendering of advice, investigation, or other such action."[16] The FAR, which has similar restrictions, defines personal and substantial participation as "active and significant involvement of the individual in activities directly related to the procurement."[17] Under the FAR, a supervisor is considered to have acted personally when they participated themselves, or directed the action of a subordinate. An action is considered to be substantial when it was "of significance to the matter." Although such definitions are not models of clarity, they do provide some warning to tell former government employees when they may be within the broad reach of the criminal post-employment restrictions. If the former government employee did participate personally and substantially in the particular matter (or contract), he or she is barred for life from ever making any communication to any officer or employee of the United States, with an intent to influence, concerning that particular matter.

Even if the former government employee did not participate "personally and substantially" in the particular matter or contract, they are still barred for two years from making any communication with an intent to influence if the matter or contract was under their "official responsibility" during the last one year of their government employment. "Official responsibility" is defined in the law as "the direct administrative or operating authority, whether intermediate or final, and either exercisable alone or with others, and either personally or through subordinates, to approve, disapprove, or otherwise direct Government action."[18]

For example, a contract that was being awarded to Company X by a subordinate contracting officer would have been under the official responsibility of the chief of contracting, even if he or she had no personal knowledge and had taken no personal action on the contract. If the chief of contracting leaves government employment within one year of the award of the contract and takes a job with Company X, he is barred for two years from making any communication with an intent to influence any Government officer or employee concerning that contract. The subordinate contracting officer, who participated personally and substantially in awarding the contract, would be barred for life from making any communication with an intent to influence any government officer or employee concerning that contract. The subordinate contracting officer's restriction applies no matter when he or she leaves government service.

The new law also provides additional restrictions on post-government employment for certain categories of former government employees. "Senior" government employees, defined as those government officers or employees paid at the level of Executive Schedule V, or military grade O-7 or higher, and "very senior" government employees, those in Executive Level

I positions or if they work in the Executive Office of the President, Executive Level II positions, have additional restrictions on communications or contacts they may make with the government after their government employment has ended. Government employees who have participated in certain trade or treaty negotiations also face additional restrictions on post-government employment activities.[19]

Proposed New Law

The wide variety of different laws which have been enacted over they years establishing ethical standard of conduct rules and post-government employment restrictions, although all aimed at the same goal of insuring ethical conduct of government employees, have created a patchwork of differing standards that seriously complicate ethical rules. The more complicated a set of rules becomes the more difficult it is to understand and comply with them. In order to clarify ethical standards of conduct laws, the Bush Administration submitted a new ethics bill for consideration by the Congress. The bill also attempts to standardize, as far as possible, ethical rules among all levels of government employees in all three branches of government.[20]

The proposed bill attempts to achieve the goals of the latest two ethics laws, the Procurement Integrity provisions and The Ethics Reform Act of 1989, while at the same time eliminating overlapping provisions from prior ethics laws. The bill would first establish a criminal offense of improper disclosure, by government employees or others, of confidential contract information such as bid, proposal or source selection information. The bill also makes it an offense for contractors or others to improperly obtain such information. The bill then provides a wide variety of remedies for those who violate the law including: criminal penalties, civil fines, adverse personnel action against government employees, suspension or debarment for contractors, and contract remedies. This portion of the proposed law is designed to fulfill that purpose of the Procurement Integrity provisions which prevented unauthorized disclosure of confidential procurement information.

The proposed bill would then repeal the Procurement Integrity law. That law currently requires all government and contractor personnel involved in a government procurement to certify that they have neither disclosed nor received confidential procurement information.

The proposed law would also repeal many overlapping post-government employment restrictions. With the enactment of the Ethics Reform Act of 1989, and its changes to the criminal restrictions on post-government employment, many of the prior laws are no longer necessary and serve mainly to complicate ethical rules and make them too difficult for many government employees to understand. The proposed law would repeal the existing Procurement Integrity law (41 U.S.C.423), 10 U.S.C. 2397a, 10 U.S.C. 2397b and 18 U.S.C. 281. It would also repeal the parallel post-government employment restrictions

effecting Department of Energy employees. All of these laws are currently suspended. In addition, the proposed bill would repeal 10 U.S.C. 2397 and 10 U.S.C. 2397c, which require former government employees and private contractors to make reports concerning employment of former government employees. Finally, it would repeal 37 U.S.C. 801, the retired pay forfeiture law that parallels the selling restriction of 18 U.S.C. 281.

Many of these prior laws do seem to overlap the uniform rules established in the Ethics Reform Act of 1989. For example, both the Procurement Integrity provision of 41 U.S.C. 423a and the recusal requirement for certain DoD officials of 10 U.S.C. 2397a prohibit government procurement officials from discussing future employment with contractors if their government duties involve that contractor's contract. 18 U.S.C. section 208a provides a criminal prohibition against any government employee acting on any matter, such as a contract, for the government if he or she is negotiating or has any arrangement concerning future employment with any contractor involved in the contract.[21] 18 U.S.C. 208a covers all government employees, not just the GS-11/O-4 or above employees who are covered by 10 U.S.C 2397a. It also applies to government employees who participate "personally and substantially" in a contract, which is virtually the same definition used to define what government employees are covered by the Procurement Integrity prohibition. Consequently, 18 U.S.C. 208a provides prohibitions which are broader than both the Procurement Integrity law and 10 U.S.C. 2397a.

Another example of overlapping laws may be found in the restriction on former government employees "switching sides," that is participating in negotiations as an employee of a contractor concerning a contract they were involved in while working for the government. The Procurement Integrity provisions (41 U.S.C. 423f), prohibit former government "procurement officials" from acting as a negotiator for a contractor for two years after last working on that contract for the government. They would face virtually the same prohibition under 18 U.S.C. 207a. Under 18 U.S.C. 207a, they would be prohibited from contacting any government officer or employee with an intent to influence them concerning the contract they had worked on while employed by the government. It would be almost impossible to act as a negotiator for a contractor if a person could make no contact with the government employees involved.

Congress adjourned without acting on the proposed new law, but since they continued the suspension of effect of the major post-government employment laws, it seems likely that they will at least consider the administration proposal before the old post-government employment restrictions come back into effect on May 31, 1991.

Summary

Procurement ethics standards and post-government employment rules have seen many changes and even now are in a state of

flux. The addition of new rules designed to combat ethical problems has added significantly to the complexity of ethical standards of conduct rules. The more complex the rules, the more difficult they are for government employees involved in procurement, and the private contractors they work with, to understand and follow them. This complexity has increased in the last few years when not only have major new laws regarding government ethics, such as the Ethics Reform Act of 1989, been added, other ethics laws, such as the Procurement Integrity provisions, have been changed. To further complicate matters, several of the existing ethical and post-government employment laws have been suspended, meaning that they have had no effect for the past year or more. Although not acted upon by the last Congress, a new law has been proposed by the Bush administration which attempts to consolidate the wide variety of existing procurement ethics and post-government employment laws to provide a more simplified standard of conduct for procurement professionals to follow.

1.P.L. 101-194, section 507 suspended these provisions from Dec. 1, 1989 to Nov. 30, 1990. P.L. 101-510, section 815 continued the suspension for most of these provisions until May 31, 1991.

2. P.L. 101-280 made changes to the Procurement Integrity law found at 41 U.S.C. 423. The new Interim FAR rules concerning procurement integrity were published in FAC 84-60 and FAC 90-2.

3.P.L. 101-28 delayed the effective date until July 16, 1989.

4.See note 1.

5.See note 2.

6.See note 3.

7.41 U.S.C. section 423(p)(2)

8.See FAR Interim Rule 3.104-6, found in FAC 84-60.

9.See 41 U.S.C. section 423(p)(2)

10.See 41 U.S.C. section 423(f)(2).

11.See 41 U.S.C. section 423(f)(3).

12.See 18 U.S.C. section 207(a)(1).

13.See HQ USAF/JACM letter dated 15 Nov 1990, paragraph B 1. However, FAR 3.104-7(b), which implements the Procurement Integrity law, indicates that some behind the scenes activities may be prohibited.

14. See 18 U.S.C. section 207(a). There are also some exceptions to the restrictions including actions which involve official duties as an officer or employee of the United States or a state or local government, or contacts concerning personal matters of the former employee (18 U.S.C 207(j).

15.See 18 U.S.C 207(i)(3).

16.See 18 U.S.C. section 207(i)(2).

17.See FAR 3.104-4(g).

18.See 18 U.S.C section 202(b).

19.See 18 U.S.C. section 207(b), (c), and (d).

20.The proposal was introduced in June 1990 as Senate Bill S-2775.

21.See 18 U.S.C 208a.

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